SALFORD HOUSE4LIFE INTERNATIONAL OPEN DESIGN COMPETITION

graduation thesis report

POLITECNICO DI MILANO

MASTER OF SCIENCE IN ARCHITECTURAL ENGINEERING

laurea magistrale nei sistemi edilizi

Relatore

Prof. Massimo Tadi

Co-Relatore

Prof. Gabriele Masera
Prof. Danilo Palazzo

mohammad reza zaker hossein

arash habibi

2013

Acknowledgements

We are grateful to have accomplished this thesis project which could be a representative of part of the contents we have learned during the Master's of Architectural Engineering course. We must be thankful to all who have supported us, namely the family, friends, colleagues and professors.

We send out our special thanks to:

Professor Tadi who has been the mail supervisor of our project and has had a sensible effect on our Architectural vision by his lectures and his points during revision of projects.

Professor Masera whose Technological design course was amongst the most instructive ones in the Master's program which definitely helps us as professional in the field to contribute towards a more sustainable world.

Professor Palazzo who was very influential on the process of our Urban Design who taught us great principles of urban design.

We also thank our other professors in Politecnico for the generous contribution of knowledge, and the well reputed Politecnico di Milano itself because of the provision of this priceless experience.

Sincerely yours,

Mohammad Reza Zaker Hossein - Arash Hibibi

Table of contents:

INTRODUCTION

chapter 1

salford house 4 Life

Chapter 1: Introduction

1.0 COMPETITION

As during design lab we were asked to find a real competition as the basis of our thesis, it was first essential to find a one that would provide basic guidelines to the project.

So upon the vast research we did, we came up to one that was very interesting, both in terms of its urban situation and location, and the competition requirements which required high standards in terms of green strategies. The competition was called ''house 4 life''. RIBA Competitions organised and managed this two stage international open design competition on behalf of former Central Salford URC, Salford City Council, and the University of Salford's Centre for Construction Innovation, NHS Salford and BRE.
The competition, launched in August 2010, invited architect-led consortia to enter an open, two-stage competition to design and build a new exemplar family housing scheme, on a 1.45ha brown-field site in the heart of the Greengate area of Salford across from Manchester city centre. The promoters were looking for a visionary development that combined innovation and sustainability whilst responding to existing and anticipated lifestyle, health and educational needs of the community.
The aim of the project is to develop new models of family housing close to the city centre that will be capable of accommodating changing housing needs over a lifetime.

1.1 project brief and requirements:

The site has been identified by the promoters as suitable for family accommodation, primarily 3-4 bedroom units, with the possibility of approx. 120 units on the site.
However the successful scheme will be significantly more than this. It will be architecturally distinctive and respond to the specific opportunities of the site. At its heart, the aims and aspirations of the competition are to:
- explore ways of promoting healthy family living, particularly in the relation of new family homes to external green spaces;

- respond creatively to issues highlighted in the Marmot Report;
- propose house types that are capable of adapting and responding to the differing housing needs of families at different stages of their lives;
- provide an exemplar of low energy, sustainable design in construction & use.

So these guide lines and vaster research into city codes and plans for future developments in the zone, British guidelines for sustainable construction and other information formed the framework for us, according to which we developed our master plans and architectural and technological design of the project.

1.2 Project Location

The project site is located within territories of The City of Salford which is a city and metropolitan borough of Greater Manchester, England. The city has a population of 218,000,[4] and is administered from the Salford Civic Centre in Swinton. It is unique in Britain having no identifiable "city centre."[1]
Here a summary of city facts is presented:

Region: North West England
Ceremonial county: Greater Manchester
Density: 5,809.3/sq mi (2,243/km^2)
Area: 37.5 sq mi (97.19 km^2)
Climate: temperate
the mean highest and lowest temp. :
13.2 °C and 6.4 °C
average hours of sunshine: 1394.5 hours

The City of Salford is bounded to the north by the boroughs of Bolton and Bury, to the south by Trafford, to the west by Wigan and to the east by Manchester.
The city's climate is generally temperate, like the rest of Greater Manchester.

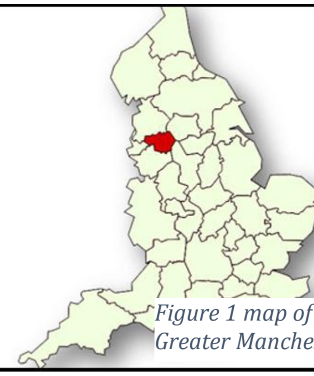


Figure 1 map of England Greater Manchester in red

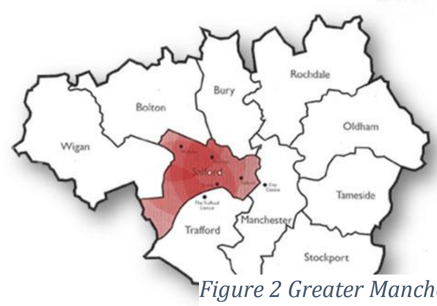


Figure 2 Greater Manchester Greater Manchester in red

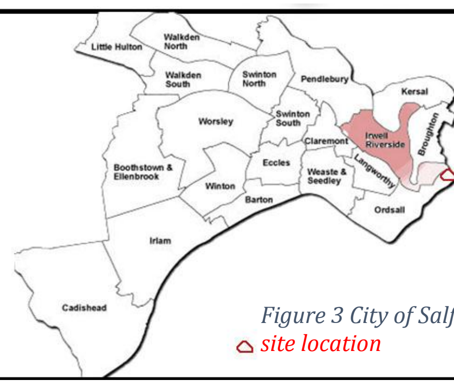


Figure 3 City of Salford site location

[1]Anon (21 August 2007). "Population estimates 2006 by district". Statistics.gov.uk.

1.2.1 Greengate:

The project site is located in Greengate area of Salford. Greengate is the new name for an area that encompasses the historic core of medieval Salford, where it started at the crossing point across the River Irwell to Manchester. Named after the main historic street that runs through the area to the river, Greengate also includes the site of Exchange Railway station, renowned for having the world's longest railway platform.

Figure 4
River Irwell Aerial view
on its left salford greengate area-on right Manchester City

Although Exchange Station no longer exists, the railway line creates a natural divide across the Greengate area as a whole, and the part of the area along the riverside, facingManchester cathedral, will be known as Greengate.
Situated right on the doorstep of Harvey Nichols, Selfridges and many of Manchester city centre's big attractions, the Salford side of the River Irwell is ideally located to become a major, high quality destination in its own right.The entire Greengate regeneration initiative will create over 3 million square feet of mixed-use development in one of the city region's most desirable locations.As a major new destination within the twin city core, Greengate has a number of exciting opportunities at different stages of development.

UNDER DEVELOPMENT:
Cathedral View: new high-end residential developments, overlooking Manchester Cathedral and the vibrant hub of Exchange Square
Greengate Arches: distinctive new mixed-use opportunities in the Grade II listed arches of the old Exchange station
Public Realm: new landscaped riverside spaces that will be a great new place to meet, eat and drink.
Almost £5m has been awarded for a mass regeneration scheme to improve the Greengate area. The site features 13 hectares of brownfield land and links Salford’s riverside and Manchester’s Medieval Quarter.
The North West Development Agency has granted £4.6m which will help maintain the momentum of the Greengate Embankment scheme which was delayed due to the recession.

1.2.2 Project Site:

Figure 5
project site and greengate area

the site specified for the competition is marked by the blue line in this figure which is on a 1.45ha brown-field site in the heart of the Greengate area of Salford across from Manchester city centre.
As greengate area acts like a buffer zone between Manchester historic attraction zone and the historical salford center, the project site is located on a ground with high potentials for further developments. These developments can further fill the gap caused by decades of ignorance in this area and can give back life to the zone.
The Planning Guidance identifies the site as suitable for 4 – 8 storey accommodation, with an element of 10 -12 storeys fronting the proposed new pocket park. However the promoters now anticipate that a development at this scale will not be viable and the scale of the development in the future is likely to be targeted at the minimum set out in the Planning Guidance.

Figure 6
project site,
river Irwell as the border between Manchester City and Salford.

1.3 Geography of Salford

The City of Salford is bounded to the north by the boroughs of Bolton and Bury, to the south by Trafford, to the west by Wigan and to the east by Manchester. The natural mossland of Chat Moss lies in the south western corner of the city; it covers an area of about 27.5 km², accounting for about 30% of the city's area, and lies 23 m above sea level.[2] The moss makes up the largest area of prime farmland in Greater Manchester. Kersal Moor is an area of moorland spanning 8 hectares (20 acres) in Kersal; it is a Local Nature Reserve and a Site of Biological Importance. Greenspace accounts for 55.7% of the City of Salford's total area, domestic buildings and gardens comprise 20.0%, and the rest is made up of roads and non-domestic buildings.[3]

Figure 7
Map of England
Greater Manchester in red

Figure 8
Greater Manchester
Salford City in red

The River Irwell runs south east through Kearsley, Clifton and Agecroft then meanders around Lower Broughton and Kersal, Salford Crescent and the centre of Manchester, joining the rivers Irk and Medlock. Turning west, it meets the Mersey south of Irlam, where the route of the river was altered in the late 19th century to form part of the course of the Manchester Ship Canal. The Ship Canal, opened in 1894, forms part of Salford's southern boundaries

---

[2] Birks (1965), p. 273
[3] "City of Salford physical environment". Statistics.gov.uk.

with Trafford.[4] The city's climate is generally temperate, like the rest of Greater Manchester. The nearest weather station is 16 km away at Ringway, in Manchester; the mean highest and lowest temperatures (13.2 °C and 6.4 °C) are slightly above the national average, while the annual rainfall (806.6 millimetres) and average hours of sunshine (1394.5 hours) are respectively above and below the national averages.[5]

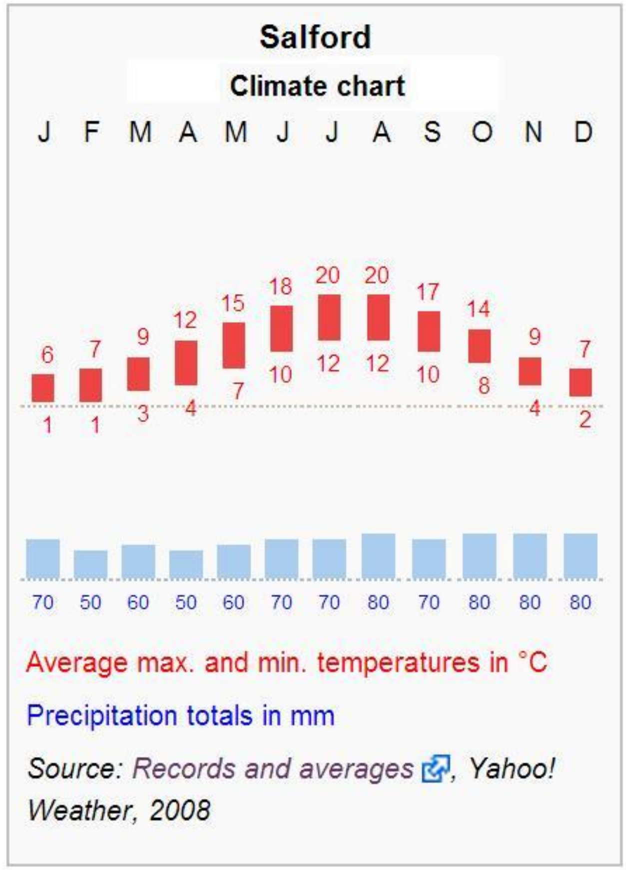


Figure 9
Salford climate chart.

1.4 Salford history

1.4.1 Toponymy

The name of Salford derives from the Old English word Sealhford, meaning a ford by the willow trees. It referred to the willows (Latin: salix) or sallows that grew alongside the banks of the River Irwell.[6] The ford was about where Victoria Bridge is today.[7] Willow trees are still found in Lower Broughton. Salford appears in the pipe roll of 1169 as "Sauford"[8] and in the Lancashire Inquisitions of 1226 as "Sainford".[9]

1.4.2 Early history

The earliest known evidence of human activity in what is now Salford is provided by the Neolithic flint arrow-heads and workings discovered on Kersal Moor and the River Irwell, suggesting that the area was inhabited 7–10,000 years ago. The raw material for such tools was scarce and unsuitable for working, and as a result they are not of the quality found elsewhere. Other finds include a neolithic axe-hammer found near Mode Wheel, during the excavation of the Manchester Ship Canal in 1890, and a Bronze Age cremation urn during the construction of a road on the Broughton Hall estate in 1873.[10] [11]

The Brigantes were the major Celtic tribe in what is now Northern England. With a stronghold at the sandstone outcrop on which Manchester Cathedral now stands, opposite Salford's

[4] Nevell (1997), p. 125.
[5] Met Office. "Annual England weather averages".
[6] Cooper 2005, p. 6.
[7] Cooper 2005, p. 7.
[8] Cooper 2005, p. 11.
[9] Cooper 2005, p. 12.
[10] Vigeon 1975, p. 1.
[11] Cooper 2005, pp. 18–19.

original centre, their territory extended across the fertile lowland by the River Irwell that is now Salford and Stretford. Following the Roman conquest of Britain, General Agricola ordered the construction of a Roman fort named Mamucium (Manchester) to protect the routes to Deva Victrix (Chester) and Eboracum (York) from the Brigantes. The fort was completed in AD 79, and for over 300 years the Pax Romana brought peace to the area. Both the main Roman road to the north, from Mamucium to Ribchester, and a second road to the west, ran through what is now Salford, but few Roman artefacts have been found in the area.[12] The withdrawal of the Romans in AD 410 left the inhabitants at the mercy of the Saxons. The Danes later conquered the area and absorbed what was left of the Brigantes.[13] Angles settled in the region during the Early Middle Ages and gave the locality the name Sealhford, meaning "ford by the willows".[14] According to the Anglo-Saxon Chronicle, Sealhford was part of the Kingdom of Northumbria until it was conquered in 923 by Edward the Elder.[15]

Following the emergence of the United Kingdom of England, Salford became a caput or central manor within a broad rural area in part held by the Kings of England, including Edward the Confessor. The area between the rivers Mersey and Ribble was divided into six smaller districts, referred to as "wapentakes", or hundreds. The south east district became known as the Hundred of Salford, a division of land administered from Salford for military and judicial purposes. It contained nine large parishes, smaller parts of two others, and the township of Aspull in the parish of Wigan.[16]

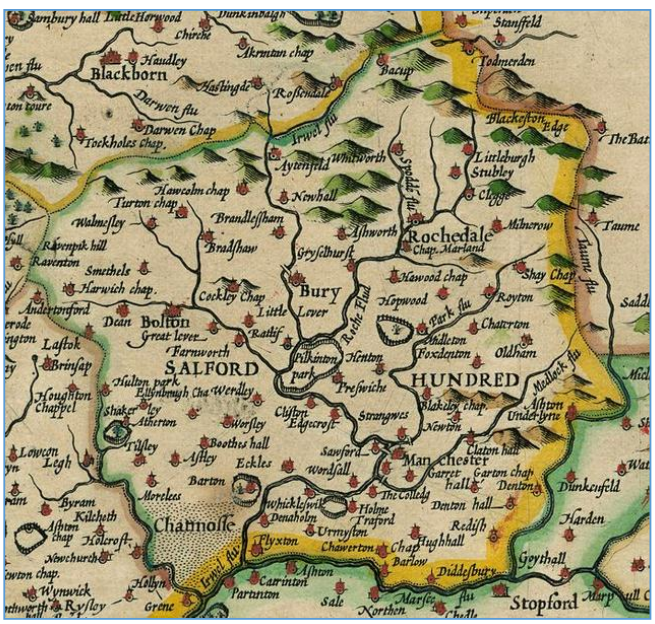


Figure 10
The Hundred of Salford was a Royal Manor of Anglo-Saxon origin centred on thedemesne of Salford.

After the defeat of the Harold II during the Norman conquest of England, William I granted the Hundred of Salford to Roger the Poitevin, and in the Domesday Book of 1086 the Hundred of Salford was recorded as covering an area of 906 km^2 with a population of 35,000.[17] Poitevin created the subordinate Manor of Manchester out of the hundred, which has since in local government been separate from Salford. Poitevin forfeited the manor in 1102 when he was defeated in a failed rebellion attempt against Henry I. In around 1115, for their support during the rebellion, Henry I placed the Hundred of Salford under the control of the Earldom of Lancaster, and it is

[12] Vigeon 1975, p. 2
[13] Bracegirdle, Cyril (1973), The Dark River, Altrincham: Sherratt, p. 18.
[14] Salford, University of Nottingham's Institute for Name-Studies.
[15] Vigeon (1975), p. 2.
[16] Kenyon 1991, pp. 166–167.
[17] Hampson 1972, p. 37.

from this exchange that the Hundred of Salford became a royal manor. The Lord of the Manor was either the English monarch, or a feudal land owner who administered the manor for the king.[18] During the reign of Henry II the Royal Manor of Salford passed to Ranulf de Gernon, 4th Earl of Chester.[19]

Salford began to emerge as a small town early in the 13th century. In 1228, Henry III granted the caput of Salford the right to hold a market and an annual fair. The fairs were important to the town; a 17th-century order forced each burgess – a freeman of the borough – to attend, but the fairs were abolished during the 19th century.[20] The Earls of Chester aided the development of the caput, and in 1230Ranulf de Blondeville, 6th Earl of Chester made Salford a burgage, or free borough.[21] The charter gave its burgesses certain commercial rights, privileges and advantages over traders living outside Salford; one of the 26 clauses of the charter stated that no one could work in the Hundred of Salford unless they also lived in the borough.[22] Salford's status as a burgage encouraged an influx of distinguished families, and by the Late Middle Ages Salford was "rich in its manor houses", with over 30 within a 5-mile (8 km) radius of Ordsall. These included Ordsall Hall (owned by the Radclyffe family) and Broughton Hall, owned by the Earls of Derby.[23]

Figure 11
Ordsall Hall is a historic house and a former stately home in Ordsall, Salford. It dates back to at least the Late Middle Agesand was the seat of the Radclyffe family.

[18] Kenyon 1991, pp. 166–167.
[19] Hampson 1972, p. 39.
[20] Vigeon 1975, pp. 4–5.
[21] Society for the Diffusion of Useful Knowledge 1841, p. 350
[22] Frangopulo 1977, pp. 135–138.
[23] Salford City Council (6 August 2003), Salford – Local History, salford.gov.uk .

During the Civil War of 1640–49, Salford supported the Royalist cause, in contrast to Manchester just across the Irwell which declared in favour of the Parliamentarians. Royalist forces mounted a siege of Manchester across what is now the site of Victoria Bridge, which although short-lived, "did little to improve relations between the two towns". A century later, in 1745, Salford was staunchly in support of Bonnie Prince Charlie, in his attempt to seize the Throne of England. He entered the town at the head of his army and was blessed by the Reverend John Clayton before leaving "in high spirits" to march on London; he returned to Salford in defeat just nine days later.[24]

1.4.3 Industrial Revolution

Salford has a history of textile processing that pre-dates the Industrial Revolution, and as an old town had been developing for about 700 years.[25] Before the introduction of cotton there was a considerable trade in woollen goods and fustians.[26] Other cottage industries prevalent at this time included clogging, cobbling, weaving and brewing.[27] The changes to textile manufacture during the Industrial Revolution had a profound effect on both on population and urbanisation, as well as the socioeconomic and cultural conditions of Salford.

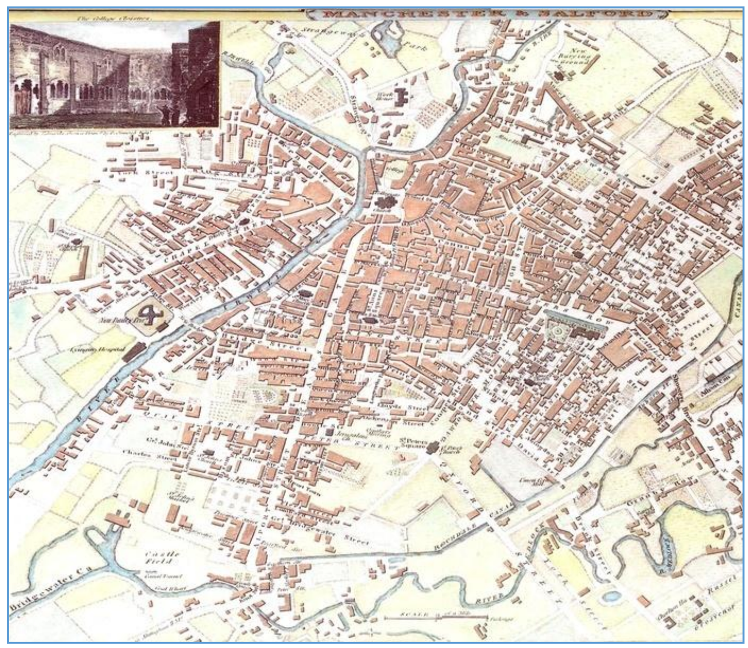


Figure 12
A map of Manchester and Salford in 1801

The well-established textile processing and trading infrastructure, and the ready supply of water from the River Irwell and its tributaries, attracted entrepreneurs who built cotton mills along the banks of the river in Pendleton and Ordsall. Although Salford followed a similar pattern of industrial development to Manchester, most businesses preferred to build their premises on the Manchester side of the Irwell, and consequently Salford did not develop as a commercial centre in the same way as its neighbour.[28] Many of these earlier mills had been based on Arkwright-type designs. These relied on strong falls of water, but Salford is on a meander of the Irwell with only a slight gradient and thus mills tended to be built upstream, at Kersal and Pendleton. With

[24] Cooper 2005, p. 23
[25] Tomlinson 1975, p. 19.
[26] McNeil & Nevell 2000, p. 42.
[27] Cooper 2005, p. 31.
[28] McNeil & Nevell 2000, p. 42.

the introduction of the steam engine in the late 18th century however, merchants began to construct mills closer to the centres of Salford and Manchester, where supplies of labour and coal were more readily available (the first steam-powered mill was built in Manchester in 1780). One of the first factories to be built was Philip's and Lee's Twist Mill in Salford, completed in 1801, the second iron-framed multi-story building to be erected in Britain. The large Salford Engine Twist Company mill was built to the west of Salford, between Chapel Street and the Irwell, and in 1806 was the first large cotton mill to use gas lighting. It was however outnumbered by the numerous smaller factories and mills throughout the area, including Nathan Gough's steam-driven mule spinning mill, near Oldfield Road, where a serious accident occurred on 13 October 1824.[29]

Canal building provided a further stimulus for Salford's industrial development. The opening of the Bridgewater Canal in 1761 improved the transport of fuel and raw materials, reducing the price of coal by about 50%. The later Manchester, Bolton & Bury Canal (which terminated at Salford) brought more cheap coal from pits at Pendleton, Agecroft Colliery and beyond. By 1818 Manchester, Salford and Eccles had about 80 mills, but it was the completion of the Manchester Ship Canal in 1894 which triggered Salford's development as a major inland port. Salford Docks, a major dockland on the Ship Canal 35 miles (56 km) east of the Irish Sea, brought employment to over 3,000 labourers. By 1914 the Port of Manchester, most of whose docks were in Salford, had become one of the largest port authorities in the world, handling 5% of the UK's imports and 4.4% of its exports. Commodities handled included cotton, grain, wool, textile machinery and steam locomotives.[30]

Figure 13
The opening of the Salford Docks turned Salford into a major inland port along the ocean-going Manchester Ship Canal. This site is now occupied by The Lowry.

For centuries, textiles and related trades were the main source of employment in the town.[31] Bleaching was a widely distributed finishing trade in Salford, carried over from the earlier woollen industry. In the 18th century, before the introduction of chemical bleaching, bleaching fields were commonplace, some very close to the town.

[29] Tomlinson 1975, pp. 25–28, p. 35.
[30] Cooper 2005, pp. 101–103.
[31] Cooper 2005, p. 31.

In 1773 there were 25 bleachers around Salford, most to the west of the township. Printing was another source of trade; the earliest recorded in the region was a calique printer in the Manchester Parish Register of 1763.[32] These industries became more important as Salford faced increasing competition from the nearby towns of Boltonand Oldham. As its cotton spinning industries faltered its economy turned increasingly to other textiles and to the finishing trades, including rexine and silk dyeing, and fulling and bleaching, at a string of works in Salford.[33]

The effect on Salford of the Industrial Revolution has been described as "phenomenal". The area expanded from a small market town into a major industrial metropolis; factories replaced cottage industries, and the population rose from 12,000 in 1812 to 70,244 within 30 years. By the end of the 19th century it had increased to 220,000. Large-scale building of low quality Victorian terraced housing did not stop overcrowding, which itself lead to chronic social deprivation. The density of housing was as high as 80 homes per acre.[34] Private roads were built for the use of the middle classes moving to the outskirts of Salford. The entrances to such roads, which included Elleray Road in Irlams o' th' Height, were often gated, and patrolled.[35]

1.4.4 Post-industrial decline

During the early 20th century, improvements in regional transport infrastructure precipitated the decline of Salford's existing industries, including those at the Salford Docks. Increased foreign competition began to undermine the competitiveness of local textile processing businesses. Rising unemployment during the Great Depression of the 1920s and '30s,[36] and a significant economic decline in the decades following the Second World War contributed toward a fall in Salford's population. By 1939 local coal mining had almost stopped, and cotton spinning had by 1971 ceased completely. Between 1921 and 1939, the population of Salford decreased by 29%, from 234,045 to 166,386,[37] far greater than the rate of decline within the whole of North West England.[38]

Figure 14
Following the demise of local manufacturing industries, a 1960s regeneration project saw the construction of over 30 tower blocks in the city, replacing many of Salford's former Victorian slums.

[32] Tomlinson 1975, pp. 23–25.
[33] McNeil & Nevell 2000, p. 42.
[34] Cooper 2005, p. 35.
[35] Hayes 2003, p. 25.
[36] Cooper 2005, p. 41
[37] *Salford MB/CB: Total Population*, Vision of Britain.
[38] *Market Renewal: Manchester Salford Pathfinder*(PDF), Audit Commission, 2003,

A survey in 1931 concluded that parts of Salford contained some of the worst slums in the country. Many houses were infested by rats and lacked elementary amenities. Inspectors found that of 950 houses surveyed, 257 were in a state of bad repair with leaking roofs, broken flooring and rotten woodwork. The inspectors were "struck by the courage and perseverance with which the greater number of tenants kept their houses clean and respectable under most adverse conditions".[39] By 1933 slum clearance projects were under way,[40] and by the end of 1956 over a thousand families had been rehoused in overspill estates at Little Hulton.[41] These clearances have, for some, changed the character of the area to such an extent that "observers in search of the typical Salford may have to look in Eccles and Swinton, for much of the community and townscape ... has gone from Salford, replaced by tall blocks of flats".[42] Large areas of the city were redeveloped in the 1960s and 1970s, with Victorian era terraced housing estates that inspired painter L. S. Lowryand soap opera Coronation Street giving way to concrete tower blocks and austere architecture. Life in Salford during the early 20th century was described by Robert Roberts, in his study The Classic Slum.[43]

Figure 15
The Housing Market Renewal Initiativehas identified Salford as having areas withterraced housing unsuited to modern needs.

Despite extensive redevelopment, throughout the 1980s and 1990s the area experienced chronic poverty, deprivation and unemployment. This social deprivation led to increased levels of gang crime linked to illegal narcotics, firearms and robberies. Organised crime in Salford, particularly in Ordsall and Pendleton, "began to have a disturbing effect on grass roots democracy. Both the Liberal Democrats and the Conservatives announced they would not contest certain Salford wards" because they regarded them as "unsafe" and would put their "party workers at risk".[44] Salford's social amenities and the night-time economy folded amid criminal "intimidation", "drug use, fights and demands for money".[45] In early 2005, the Government of Latvia appealed to the European Union to advise people against travelling to Salford after a Latvian man was stabbed in the head in Lower Broughton. However, a crackdown by Greater Manchester Policecoupled with investment in, and structural changes to the housing stock, began the change in Salford's fortunes;[46] population decline has slowed, and Salford's city councillors have insisted it is a safe place to visit. In August 2005, a survey by Channel 4 television rated the city as the 9th worst place to live in the United Kingdom, based on criteria of crime, education, environment, lifestyle and employment.[47]

[39] Cooper 2005, p. 41
[40] Manchester Evening News Staff 2007, p. 5
[41] Manchester Evening News Staff 2007, p. 12
[42] Clark 1973, p. 14.
[43] Davey Smith, Dorling & Shaw 2001, p. 301
[44] Walsh 2003, pp. 118–122.
[45] Walsh 2003, p. 124.
[46] Walsh 2003, pp. 264–266.
[47] *Hull "worst place to live in UK"*, BBC News, 10 August 2005,

1.5 Governance

1.5.1 Parliamentary constituencies

Figure 16
Salford Civic Centre, in Swinton

The residents of the City of Salford are represented in the British Parliament by Members of Parliament (MPs) for three separate parliamentary constituencies. Salford and Eccles is represented by Rt Hon Hazel Blears MP (Labour).[48] Worsley and Eccles South, is represented by Barbara Keeley MP (Labour).[49] The Broughton and Kersal wards of Salford are part of the Blackley and Broughton constituency which is represented by Graham Stringer MP (Labour).[50] The City of Salford is part of the North West England constituency in the European Parliament. North West England elects nine MEPs, as at 2008 made up of four Conservatives, three from the Labour Party, one Liberal Democrat, and one member of the United Kingdom Independence Party.[51]

1.5.2 Council

In 1974, Salford City Council was created to administer the newly formed local government district. Until 1986, it shared power with the Greater Manchester County Council. The council offices are located in Swinton, in what was formerly the Swinton and Pendlebury town hall. The Labour Party have been in control of the council since its formation in 1974.[52] The council has a constitution detailing how they should operate in performing their duties.[53]

Party	Seats		Current Council (2012)
	2011	2012	
Labour	*44*	*52*	
Conservative	*11*	*8*	
Lib Dems	*3*	*0*	
Independent	*2*	*0*	

Figure 17
Party political of make-up of Salford Council

[48] "Salford and Eccles constituency election results.". Guardian.co.uk.
[49] "Worsley and Eccles South constituency election results". Guardian.co.uk.
[50] "Blackley and Broughton constituency election results". Guardian.co.uk.
[51] "UK MEPs". Europarl.org.uk. Archived from the original on February 21, 2008.
[52] "Vote 2012: Salford". *BBC News*.
[53] City of Salford Borough Council. "The council's constitution". Salford.gov.uk.

Salford City Council was assessed by the Audit Commission and judged to be "improving well" in providing services for local people. Overall the council was awarded "three star" status meaning it was "performing well" and "consistently above minimum requirements", similar to 46% of all local authorities.[54]

The modern metropolitan borough of the City of Salford is based on the former County Borough of the City of Salford which included the city centre, Pendleton, Weaste, Claremont, Langworthy, Broughton, Kersal, Ordsall and Seedley. The city is entirely unparished and absorbed the municipal boroughs of Eccles and Swinton and Pendlebury and the urban districts of Irlam and Worsley. An urban district was a type of local government district which covered an urbanized area.

1.5.3 Electoral wards

There are 60 councillors representing 20 wards. Swinton and Walkden have six councillors each.[55]

Ward name	Area (ha)/mi^2	Population	Population density (people per hectare)
Boothstown and Ellenbrook	860 hectares (3.3 sq mi)	9,799	11.4
Ordsall	414 hectares (1.60 sq mi)	6,554	15.8
Cadishead	1,476 hectares (5.70 sq mi)	9,289	21.9
Worsley	838 hectares (3.24 sq mi)	9,964	22.6
Irwell Riverside	451 hectares (1.74 sq mi)	11,571	25.7
Pendlebury	662 hectares (2.56 sq mi)	11,499	27.7
Irlam	935 hectares (3.61 sq mi)	9,868	28.9
Weaste and Seedley	354 hectares (1.37 sq mi)	10,913	30.8
Little Hulton	452 hectares (1.75 sq mi)	12,713	32.8
Walkden North	448 hectares (1.73 sq mi)	11,241	36.0
Kersal	313 hectares (1.21 sq mi)	11,305	36.1
Walkden South	361 hectares (1.39 sq mi)	10,170	36.4
Eccles	270 hectares (1.0 sq mi)	10,298	38.2
Swinton South	281 hectares (1.08 sq mi)	10,993	39.1
Swinton North	349 hectares (1.35 sq mi)	11,000	43.3
Winton	370 hectares (1.4 sq mi)	12,199	44.1
Broughton	267 hectares (1.03 sq mi)	11,861	44.4
Barton	244 hectares (0.94 sq mi)	12,067	47.4
Claremont	190 hectares (0.73 sq mi)	10,484	55.2
Langworthy	203 hectares (0.78 sq mi)	12,373	61.2

Figure 18
Salford electoral wards.

[54] "Salford City Council comprehensive performance assessment (CPA) scorecard 2007". Audit Commission. 2007.
[55] "City of Salford Council Wards".

1.6 Central Salford and Salford West

The district is divided into two areas (Central Salford and Salford West) for some purposes including planning, regeneration and housing.

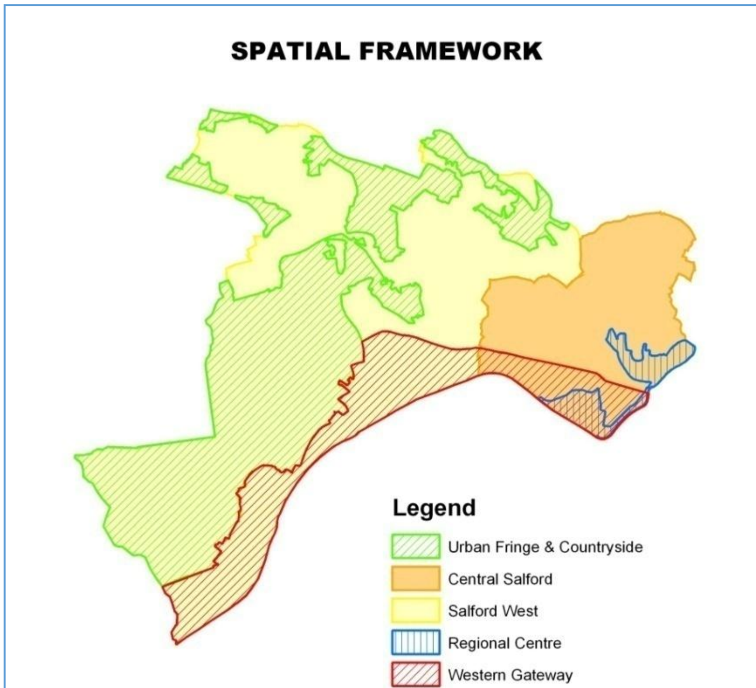


Figure 19
Central Salford and Salford West.

1.6.1 Central Salford is the eastern part of the district and comprises seven wards: Broughton, Claremont, Irwell Riverside, Kersal, Ordsall, Langworthy and Weaste & Seedley. This is the more urban half of the district and lies partly within the Manchester Inner Ring Road. Salford Quays lies within this area. Between 2005 and 2011, the Central Salford Urban Regeneration Company was responsible for urban regeneration in this area, securing over £1 billion of private sector investment. Social housing is provided by Salix Homes in this area.

1.6.2 Salford West comprises the other wards. The main settlements in Salford West are Eccles, Swinton and Walkden. This is the more suburban and rural half of the district. Salford City Council's aspiration is that "In 2028, Salford West will be one of the most desirable and prosperous areas in Greater Manchester." Social housing is provided by City West Housing Trust in this area.

1.7 Demography

As of the 2001 UK census, the City of Salford had a total population of 216,103. Of the 94,238 households in Salford, 29.3% were married couples living together, 36.7% were one-person households, 8.5% were co-habiting couples and 12.5% were lone parents. The figures for lone parent households were above the national average of 9.5%, and the percentage of married couples was also below the national average of 36.5%; the proportion of one person households was higher than the national average of 30.1%.

The population density was 2,223 /km^2 (5,760 /sq mi) and for every 100 females, there were 96.6 males. Of those aged 16–74 in Salford, 35.5% had no academic qualifications, significantly higher than 28.9% in all of England. 5.3% of Salford's residents were born outside the United Kingdom, significantly lower than the national average of 9.2%.[56] The largest minority group was recorded as Asian, at 1.4% of the population.[57]

[56] "Salford Metropolitan Borough country of birth data". Statistics.gov.uk.
[57] Statistics.gov.uk.

The number of theft from a vehicle offences and theft of a vehicle per 1,000 of the population was 21.3 and 7.9 compared to the English national average of 7.6 and 2.9 respectively. The number of sexual offences was 1.1 compared to the average of 0.9. The national average of violence against another person was 16.7 compared to the Salford average of 27.2.[58] The figures for crime statistics were all recorded during the 2006/7 financial year.[59] Although all were above the averages for England, Salford's crime rate was lower than Manchester's.[60]

1.7.1 Population change

The table below details the population changes since 1801, including the percentage change since the last available census data. Although the City of Salford has existed as a metropolitan borough since 1974, figures have been generated by combining data from the towns, villages, and civil parishes that would later be constituent parts of the city.[61]

Population growth in City of Salford since 1801

Year	1801	1811	1821	1831	1841	1851	1861	1871	1881	1891	1901	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001	2011
Population	29,495	38,460	49,114	68,744	91,361	108,699	148,740	188,781	228,822	265,000	296,210	331,098	333,031	334,989	318,152	302,160	291,240	280,739	241,532	230,726	216,103	233,900
% change	–	+30.4	+27.7	+40.0	+32.9	+19.0	+36.9	+26.9	+21.2	+15.8	+11.8	+11.8	+0.6	+0.6	−5.0	−5.0	−3.6	−3.6	−14.0	−4.5	−6.3	+8.2

Source: *Vision of Britain*

Figure 20
Salford population change since 1801

1.8 Physical Characteristics of Salford

1.8.1 Topography

Topographically the city is formed of a ridge of higher land lying between a stretch of the River Irwell to the north east, and the low lying Chat Moss area to the south west. The ridge of high land (which nowhere reaches more than 115 m above sea level) extends from the north-western boundary of the city with Bolton / Wigan, eastwards for 6 -7 miles, before dropping down to meet the start of the lower reaches of the River Irwell (sections of which were developed to form the Manchester Ship Canal). A narrow strip of higher land also runs northeast to southwest along the side of the Ship Canal.

1.8.2 Geology

Coal measures underlie the higher land, and are covered by deposits from the Ice Age. These glacial deposits provided the materials from which most of the soils were formed and on which the natural habitats of the area developed. In the low lying areas of land adjoining the lower reaches of the River Irwell (now the Manchester Ship Canal), where drainage was impeded following the Ice Age, substantial layers of peat were laid down which gradually developed into extensive peat bogs raised above the level of the surrounding land. Between the River Glaze and Worsley / Eccles, these peat bogs became known as Chat Moss (moss is the local name for lowland peat bog).

58 "Local Area Crime Figures for Salford". UpMyStreet.co.uk. 2006/7.
59 "Local Area Crime Figures for Salford - Learn More section". UpMyStreet.co.uk. 2006/7.
60 "Local Area Crime Figures for Manchester". UpMyStreet.co.uk. 2006/7.
61 "Salford District: total population". Vision of Britain.

1.8.3 Landscape

Historically Salford itself developed adjacent to the Irwell, but outlying settlements such as Worsley, Irlam, Cadishead and Pendlebury gradually developed on the higher land, avoiding the lower land and the extensive peat bogs. Later however more development took place in the Irwell flood plain and as the mosslands were drained on Chat Moss. This development has led to an open landscape on Chat Moss of regular shaped fields in agricultural production, bounded by deep ditches and interspersed with blocks of mature woodland. In the more heavily degraded urban landscape, built development straddles key transport routes, but there is a narrow corridor of open grassland and pockets of semi natural habitats extending along the Irwell valley.

1.8.4 Land Use

Despite the extensive development of the higher land, the 2000 Phase 1 Habitat Survey estimated that of the 9,721 ha making up the total area of the city, some 4,130 ha (or 42.5%) was composed of open land and water. Of the open land in the city, 1,118 ha are covered by arable crops (largely on Chat Moss) and 681 ha by amenity grassland (largely within recreation grounds, parks and playing fields in the urban areas). Of the open water 36 ha were composed of standing water such as reservoirs, lakes and ponds and 92 ha by running water, such as rivers and canals.

1.9 Salford's Biodiversity

For the purposes of the 2000 habitat survey, built up land was taken to include employment areas, houses and gardens, roads, railways, shops and car parks, while open land and water included agricultural land, recreation grounds, playing fields, woodlands, golf courses, ponds, canals, reservoirs and rivers.

Chapter 2: Urban Design

2.1 Analysis

Salford City is under a state of changing fast. Neglected and forgotten areas are being transformed and a confident, modern Salford is emerging. With the people of Salford at its heart, the City's transformation is guided by a new Vision and Regeneration Framework, which was the direct result of extensive consultation with communities throughout Central Salford and has been agreed by all partners.

2.1.1 Salford City context

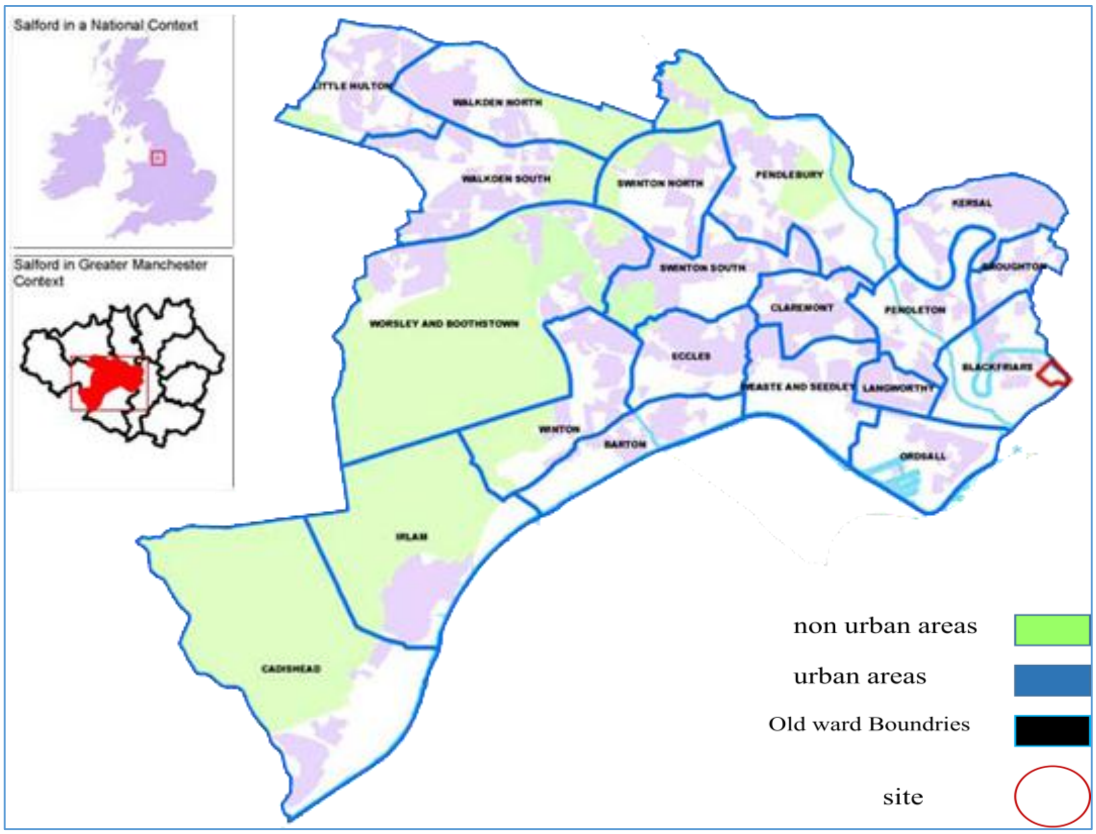


Figure 21
Salford City context

As it is shown in the figure above, we can see Salford City and the ward division. Salford is divided by 20 wards. There are shown the urban and non urban areas of the Salford City and the site location on the western side of the city context .

2.1.2 Salford City Tenure

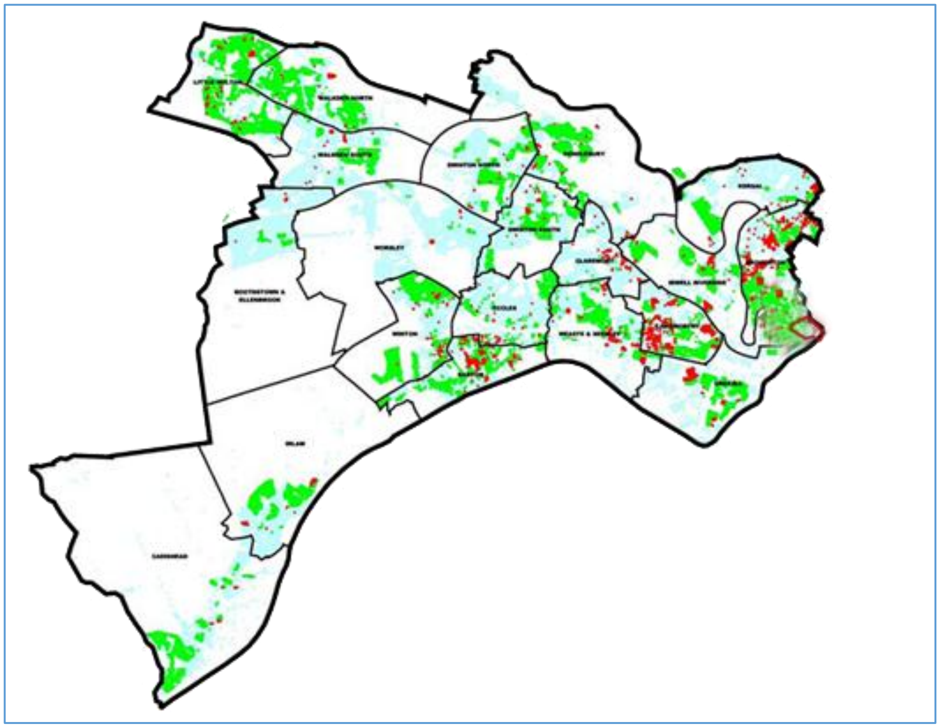


Figure 22
Salford City tenure

Council housing in Salford is provided by the arms-length management organisation (ALMO), Salix Homes. Homes previously owned by the council in west Salford are now owned and managed by the Registered Social Landlord (RSL), City West Housing Trust.

2.1.3 Green space

2.1.3.1 strategic semi-natural greenspace

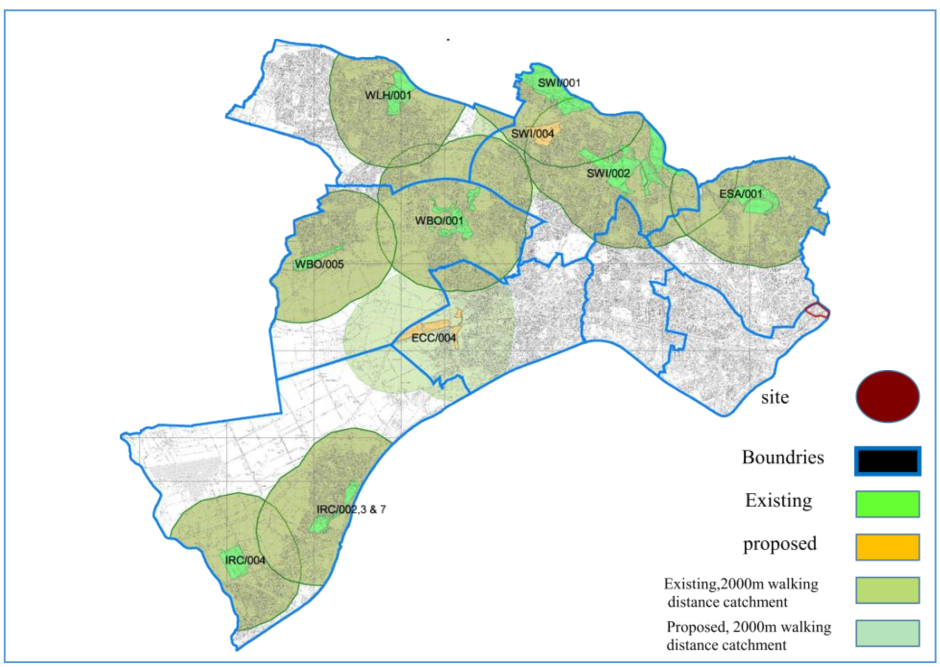


Figure 23
Strategic semi-natural greenspace

The purpose of Salford Greenspace Strategy is to protect and enhance Salford's greenspace resource by improving accessibility to good quality green space provision. Strategic semi-natural greenspaces in Salford are accessible for 91.99% of the residents of each zone within 25 minutes.

2.1.3.2 Neighborhood Parks

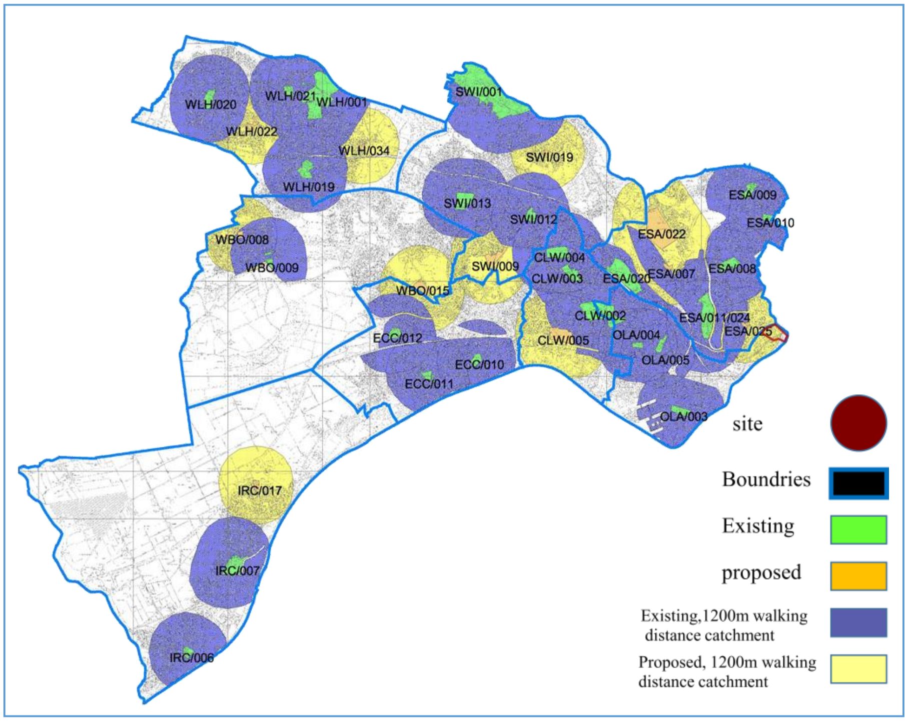


Figure 24
Neighborhood parks

Neighborhood parks, which generally range in size up to 120,000 m^2, serve as a social and recreational focal points for neighborhoods and are the basic units of a park system. Many include a playground.

Neighborhood parks provide relief from the built environment for residents. Neighborhood parks are largely accessible by foot, bicycle, or public transit within at least a quarter-mile radius from residences, providing easy access especially for children and senior adults.

2.1.3.3 Open space

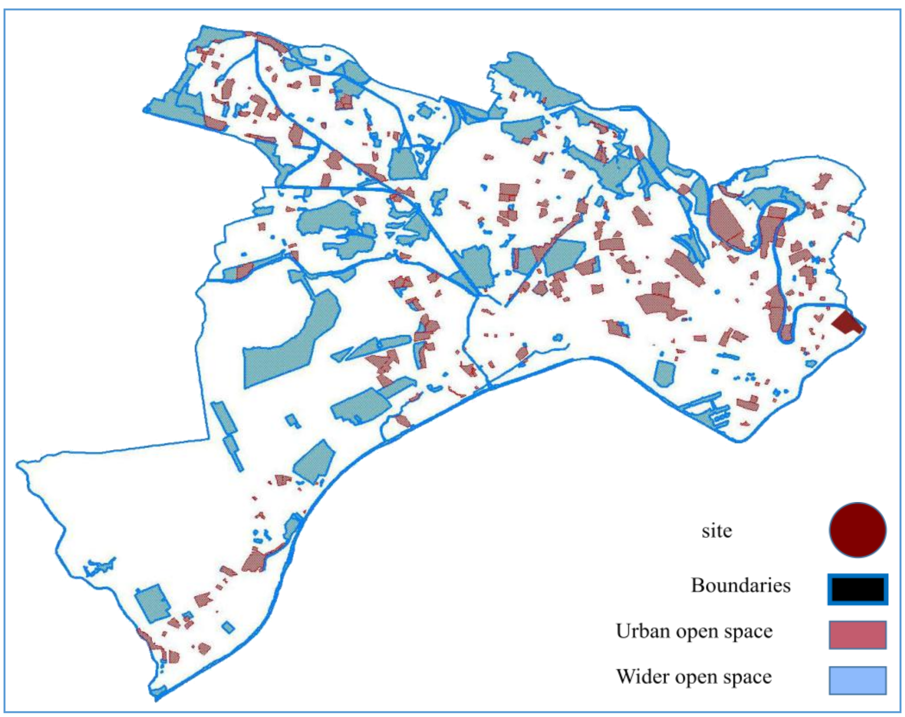
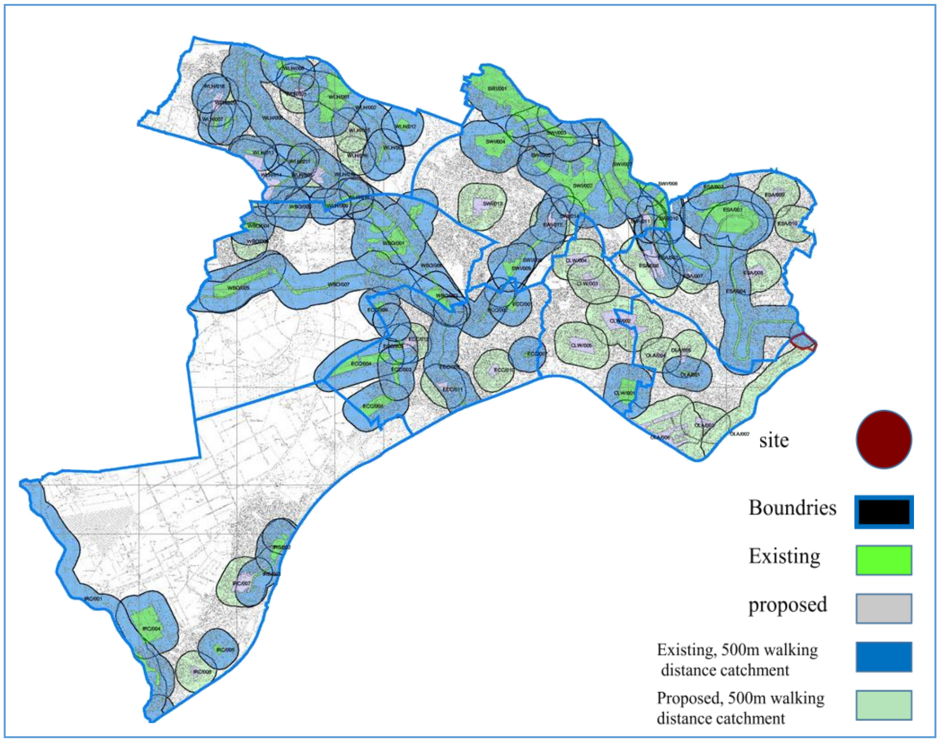


Figure 25
Open space

There are many different types of public open space. Each one is physically unique, of course, and reflects both its locality and community. They may include a mix of different land types and uses. Playgrounds and waterways, wildlife areas, allotments and gardens, parks and cemeteries make up a rich mosaic of public space.

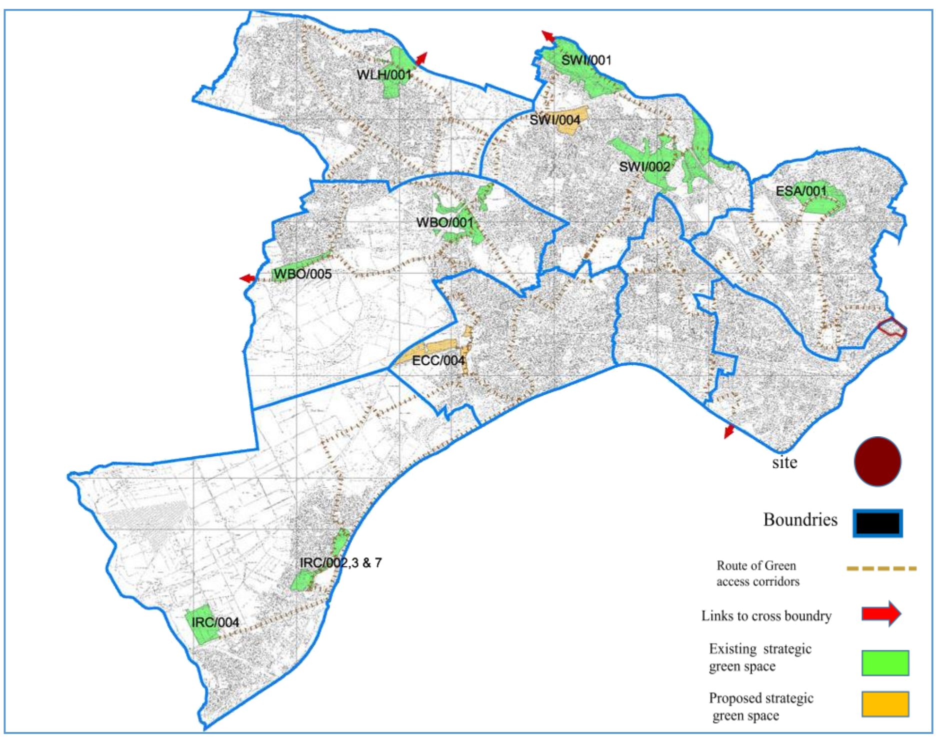
2.1.3.4 local semi-natural Greenspace



According to 2009/10 measures of Salford City Council local semi-natural greenspaces in Salford are accessible for 46.22% of the residents of each zone within 5 minutes.

Figure 26
Local semi-natural greenspace

2.1.3.5 Route of Green access corridors



By developing green access corridors along key pedestrian and cycle routes and developing connections to greenspace it is ensured all neighborhoods have safe and easy access to open space.

Figure 27
Route of Green access corridors

2.1.3.6 Maps of Strategy

Figure 28
Distance toPeel park: 1,3 Km

Figure 29
Distance to Ordsall park: 2,3 Km

2.1.4 Public space

A public space is a social space that is generally open and accessible to people. Roads (including the pavement), public squares,parks and beaches are typically considered public space. Government buildings which are open to the public, such as public libraries are public space.

2.1.4.1 Strategic sport pitches

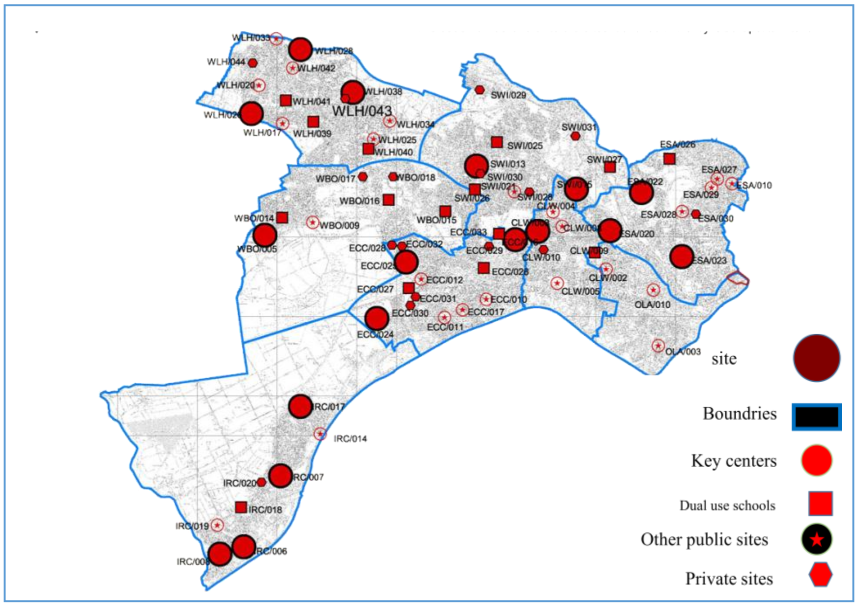


Figure 30
Strategic sport pitches

Salford City Council is a major provider of sports pitches. This provision is complemented by facilities in the education, voluntary and private sectors. Current provision and access to facilities is uneven across the city, and the quality of pitches and ancillary facilities has a significant bearing on their level of use.

2.1.4.2 Play demand

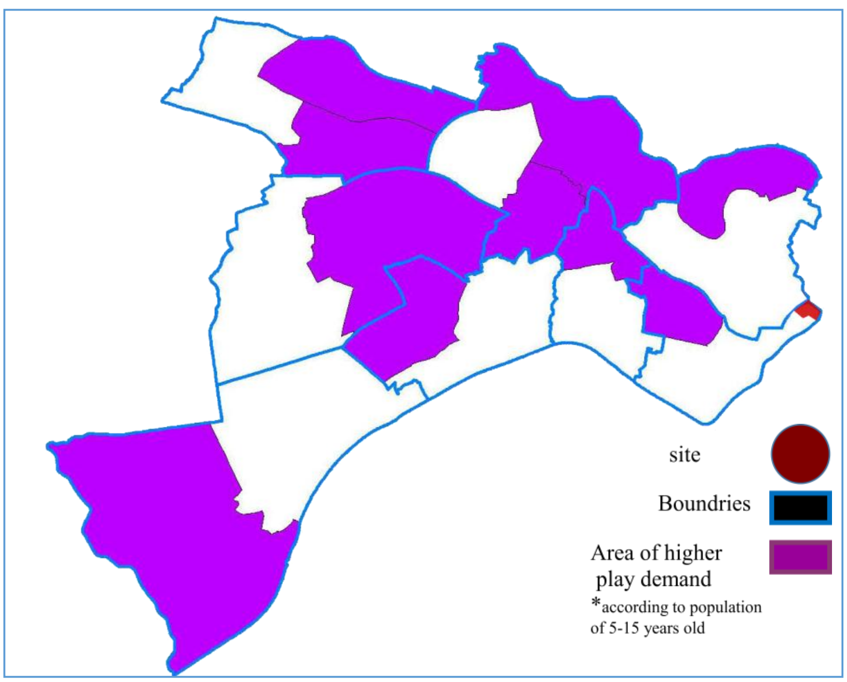


Figure 31
Playing demand

The population of Salford is expected to continue to grow in future years, which is likely to increase pressures for the development of land in and around urban areas and green spaces (including playing fields).

2.1.5 Housing strategies

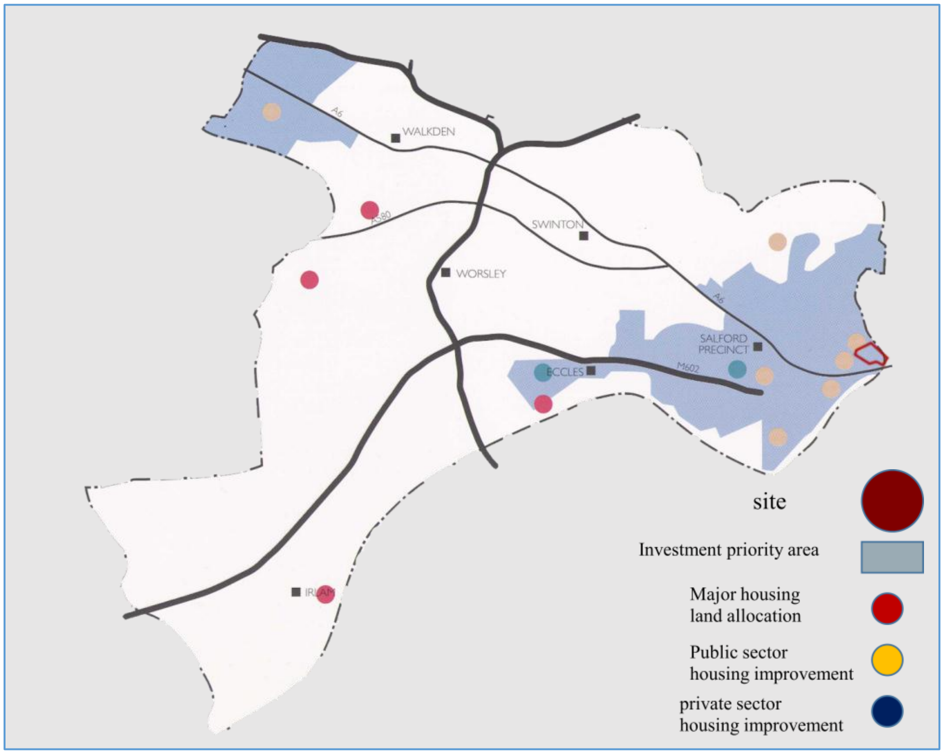


Figure 32
Housing strategy diagram 1

A housing strategy is an effective long-term way of assessing, planning and meeting the varied housing requirement in Salford. Strategies can be general like the city's housing strategy, which looks at all aspects of housing in Salford, or can be specific to a particular theme or client group.

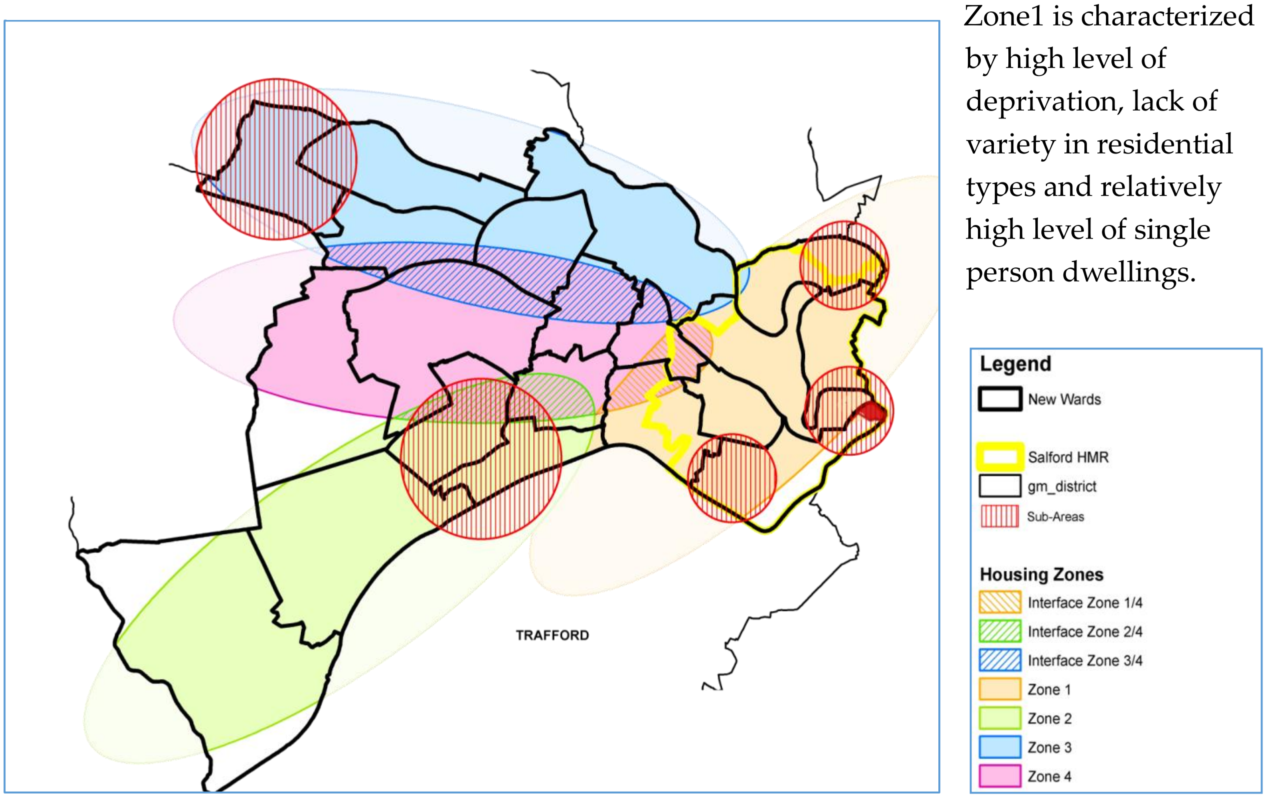
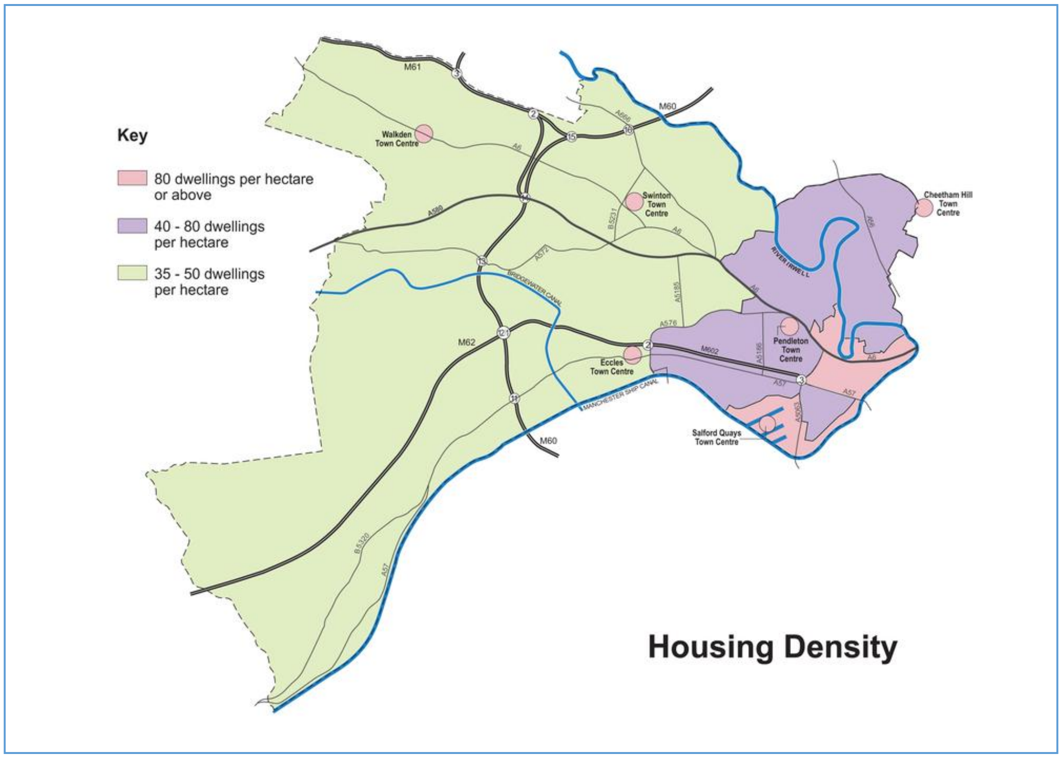


Figure 33
Housing strategy diagram 2

Zone1 is characterized by high level of deprivation, lack of variety in residential types and relatively high level of single person dwellings.



West Salford is much less densely populated than central Salford as these areas have much more green space.

Figure 34
Housing strategydiagram 3

2.1.6 Population change

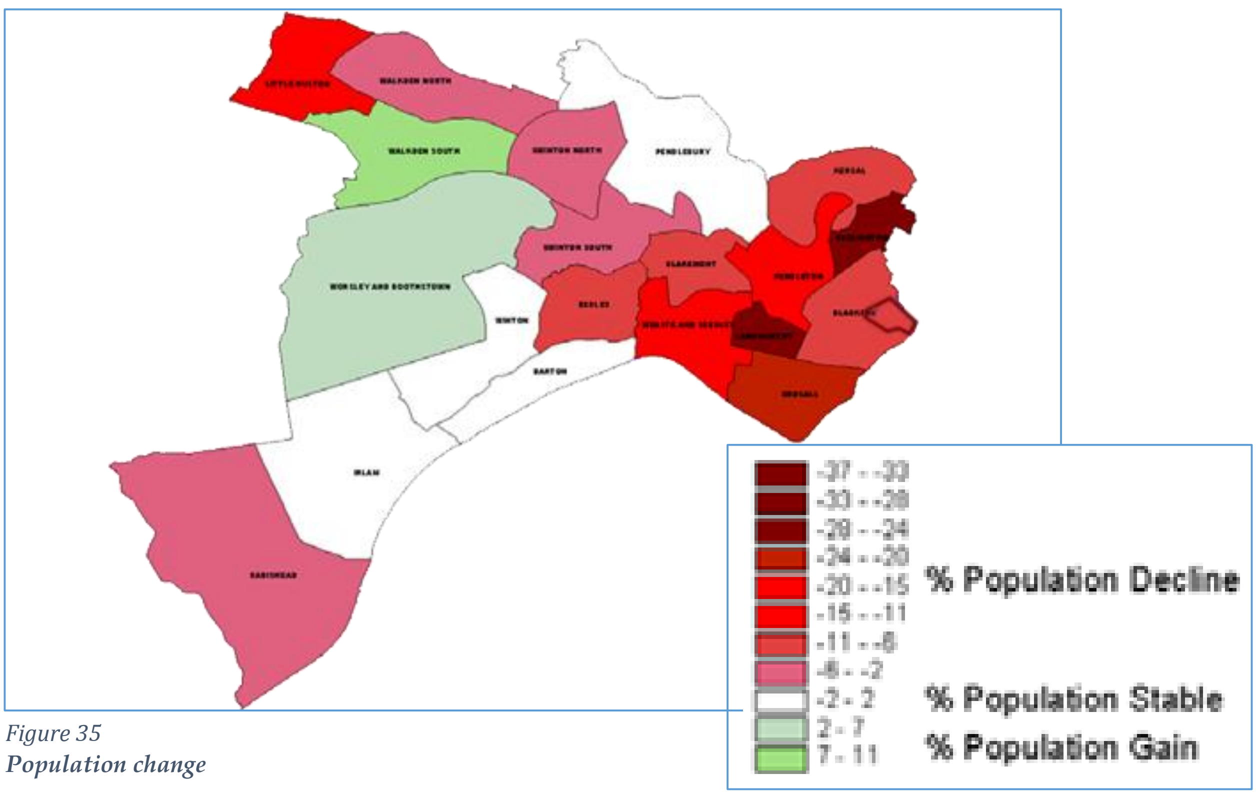
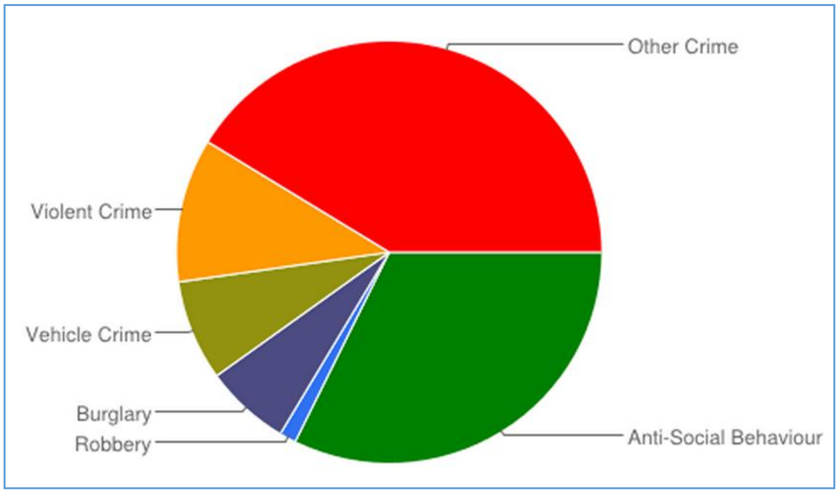


Figure 35
Population change

2.1.7 Threats



The number of theft from a vehicle offences and theft of a vehicle per 1,000 of the population was 21.3 and 7.9 compared to the English national average of 7.6 and 2.9 respectively. The number of sexual offences was 1.1 compared to the average of 0.9. The national average of violence against another person was 16.7 compared to the Salford average of 27.2.[62] The figures for crime statistics were all recorded during the 2006/7 financial year.[63] Although all were above the averages for England, Salford's crime rate was lower than Manchester's.[64]

2.1.7.1 Total number of crimes

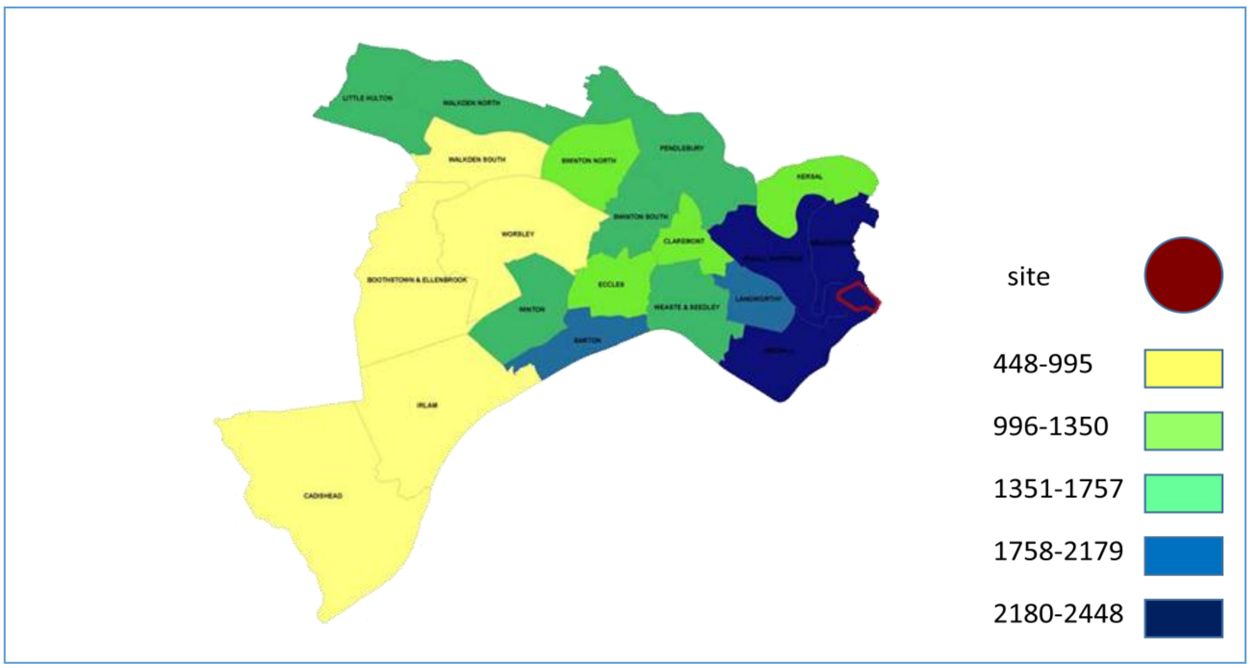


Figure 36
Total number of crimes

[62] "Local Area Crime Figures for Salford". UpMyStreet.co.uk. 2006/7.
[63] "Local Area Crime Figures for Salford - Learn More section". UpMyStreet.co.uk. 2006/7.
[64] "Local Area Crime Figures for Manchester". UpMyStreet.co.uk. 2006/7.

2.1.7.2 Vehicle crimes

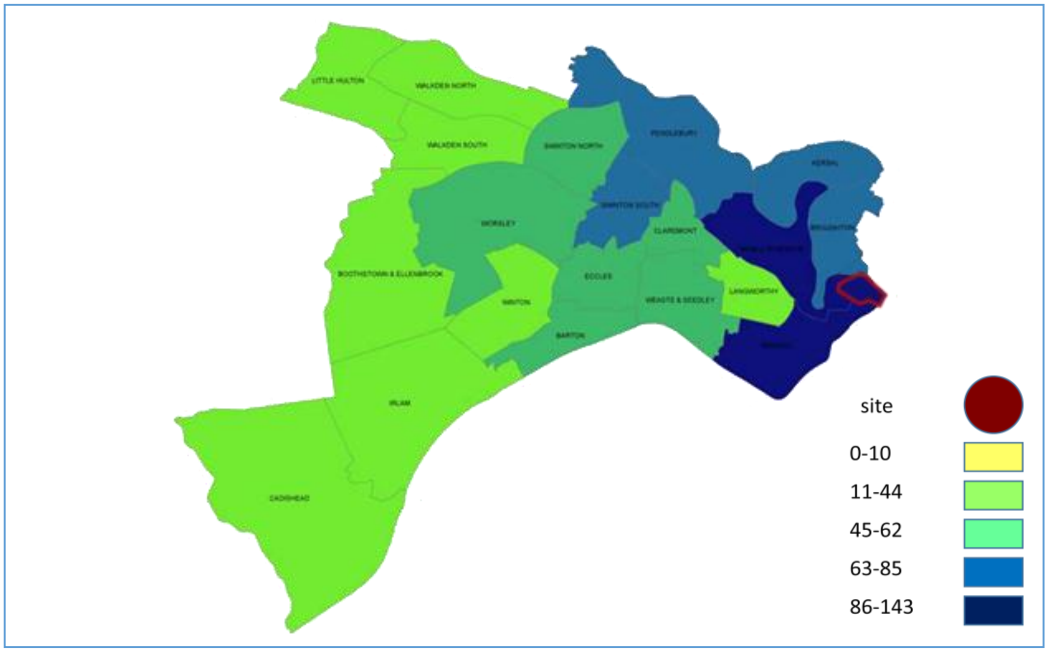


Figure 37
Vehicle crimes
** Rate per 1000 dwellings*

The Crumpsall and Cheetham area, immediately to the north of the city centre, had the worst car crime tally of any suburb, with 734 crimes in 2011. The neighbouring district of Salford East, which includes Broughton and Kersal, followed close behind with 722.

2.1.7.2 Vacancy rates

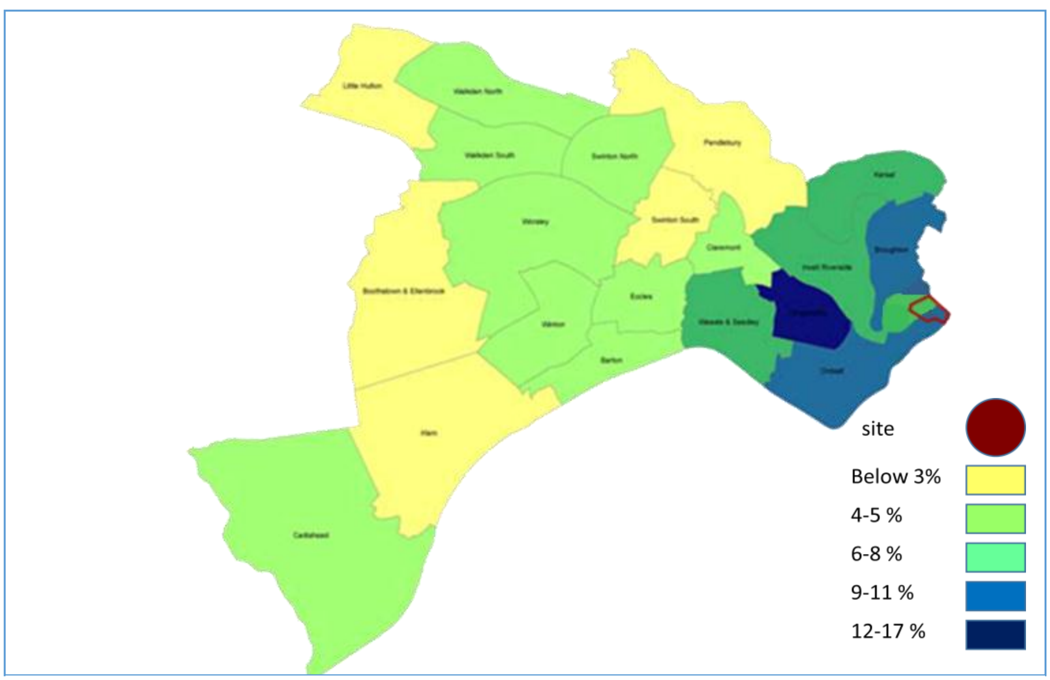


Figure 38
Vacancy rate(%)

2.2 The Irwell corridor

The River Irwell forms the boundary between Manchester and Salford and empties into the River Mersey near Irlam.

2.2.1 The Irwell corridor analysis

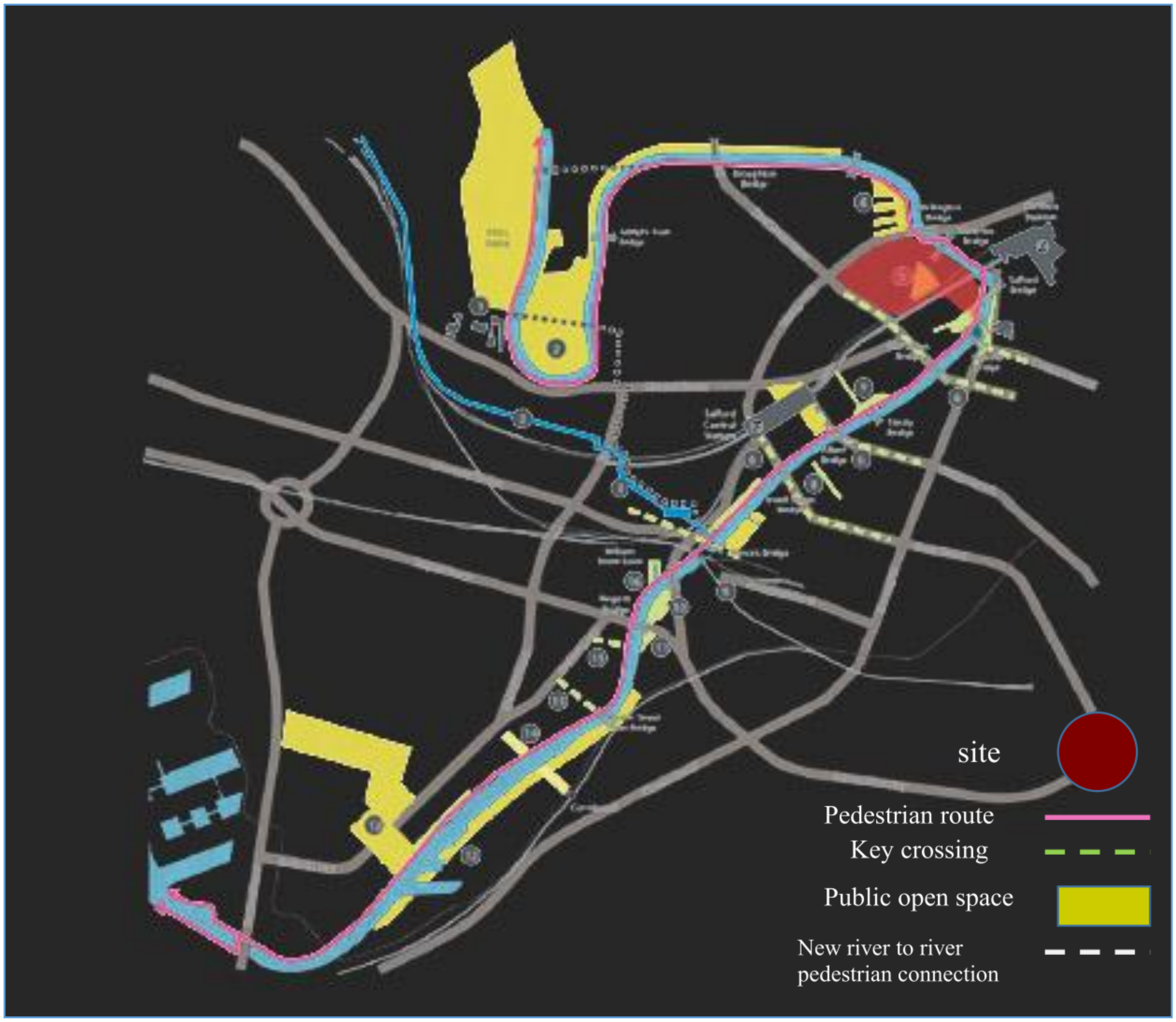


Figure 39
The Irwell corridor connections

The Irwell River connection is a vision of a river and its corridor, which has been reclaimed by its surrounding communities; of a river transformed from a barrier into a meeting place; of a river moved from the periphery to the very heart of the cities' shared life and identity.

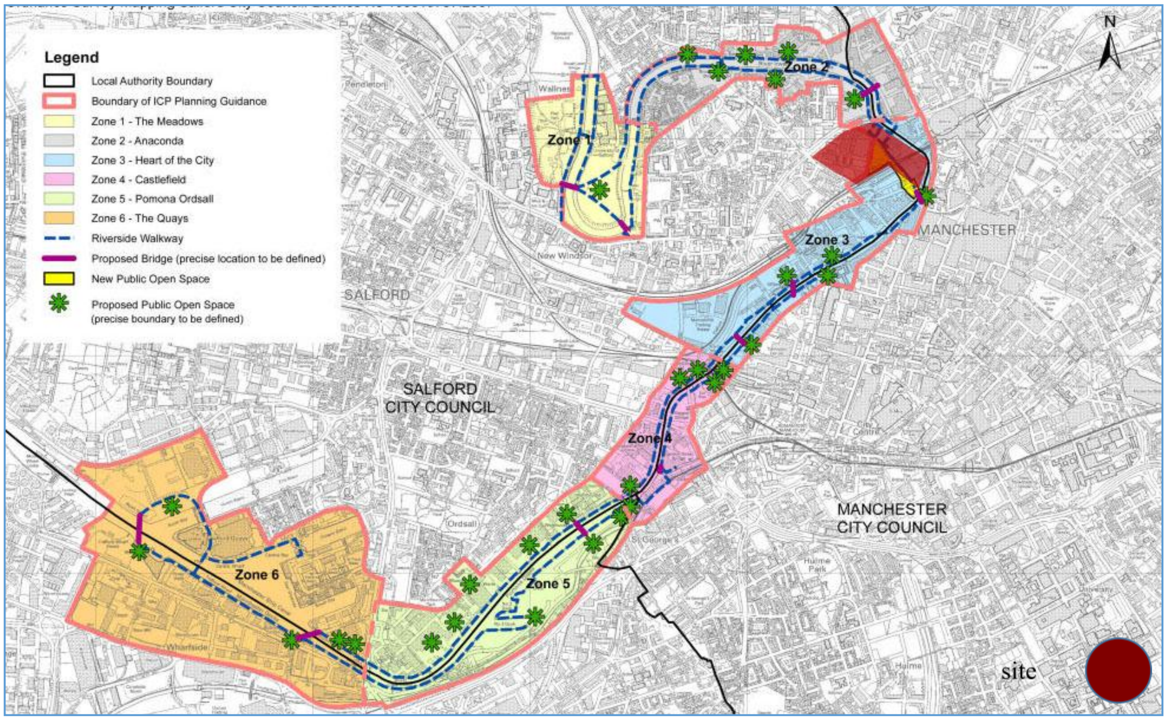


Figure 40
Irwell corridor zone analysis

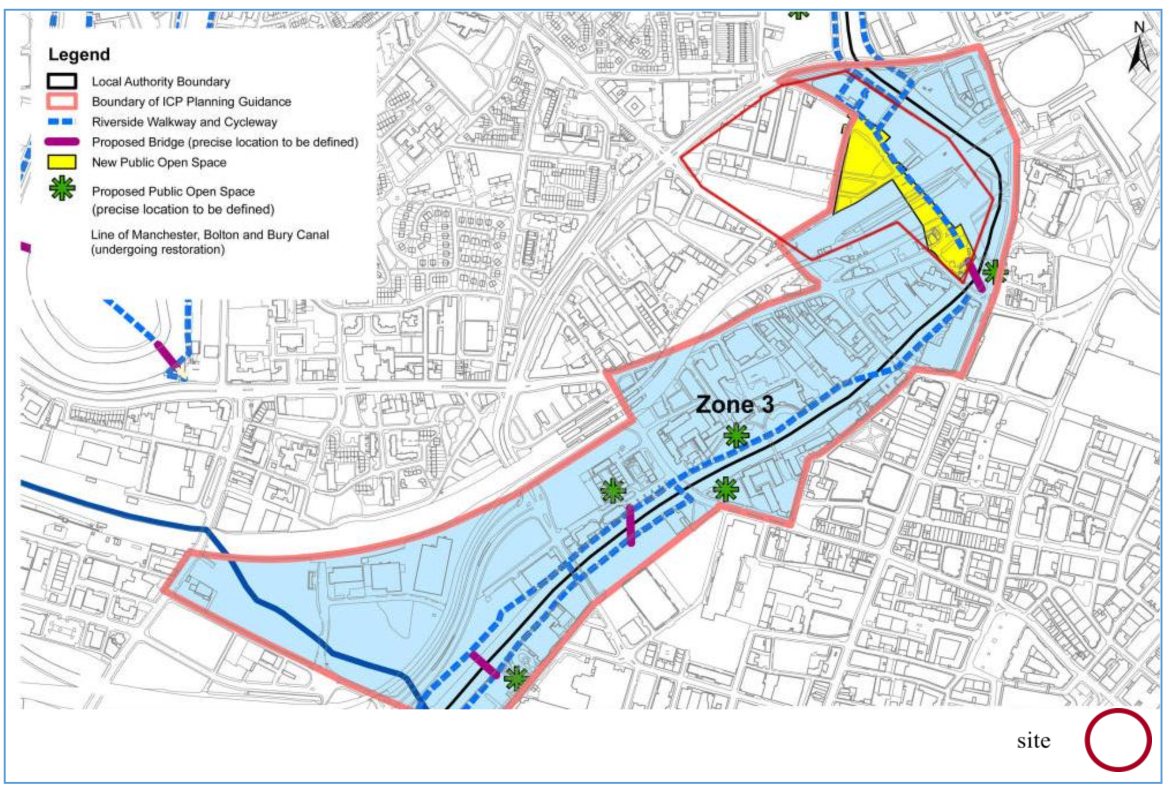


Figure 41
Irwell corridor zone 3 analysis

2.3 Overview on important city spots

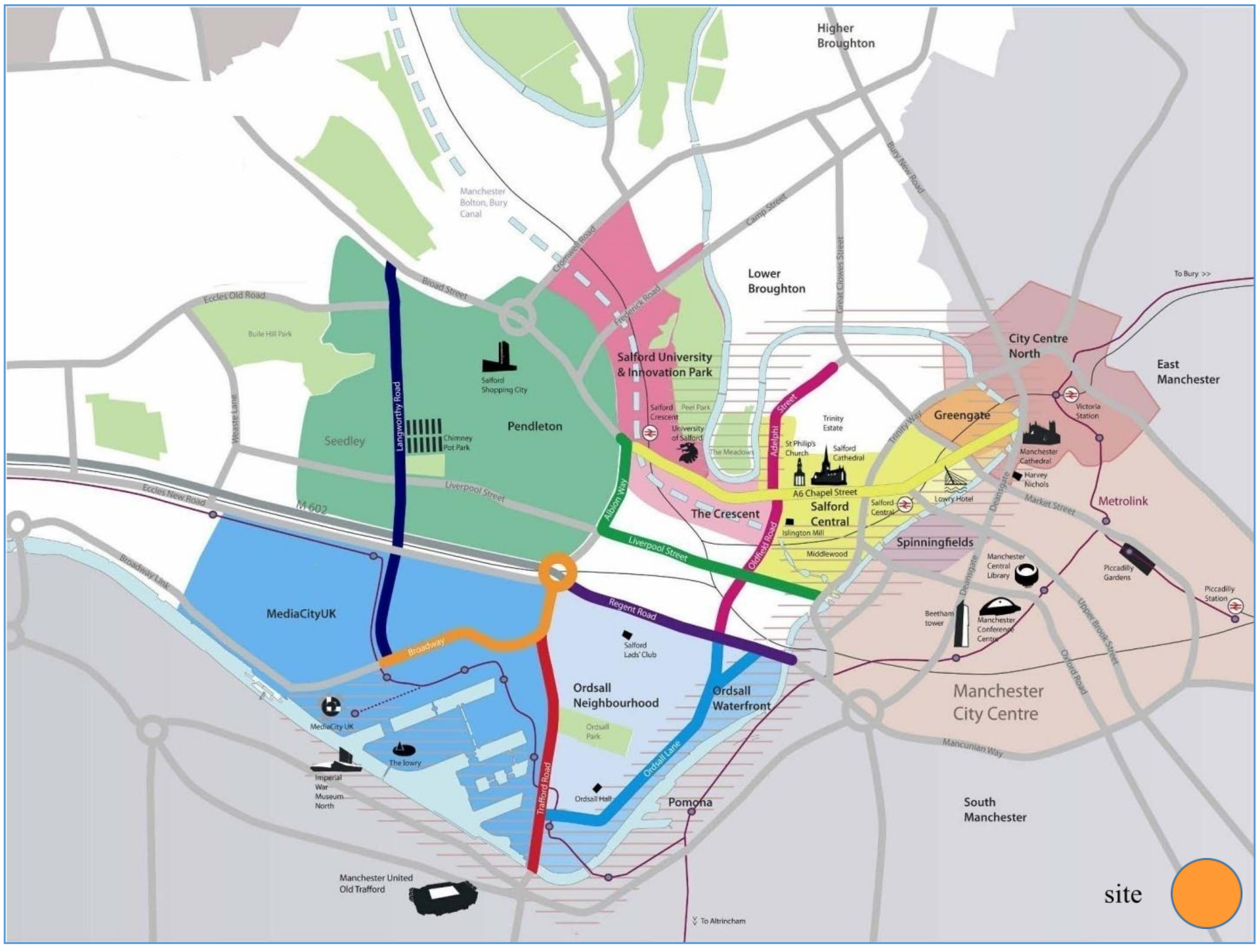


Figure 42
Important city spots

2.3.1 Landmarks

As of September 2003, the City of Salford has 6 Grade I, 14 Grade II*, and 253 Grade II listed buildings. The city has the equal second highest number of Grade I listed buildings out of the districts of Greater Manchester, behind Manchester. The Grade I listed buildings are the Church of St Augustine, the Parish Church of St Mary the Virgin, St Mark's Church, Ordsall Hall, Wardley Hall, and a bridge over the River Irwell. Salford Cathedral, built in 1845, is the seat of the Diocese of Salford and a Grade II* listed building. Most of the Salford's tallest buildings are mid-20th century residential tower blocks or 21st century high rise apartments. A study by Professor Christopher Collier of the University of Salford suggested that Manchester's drizzly climate is largely due to the multitude of high-rise blocks in Salford. Collier has proposed that they have a "dramatic influence on the region's weather patterns", and may contribute to the 8 °C (14 °F) temperature difference between Salford and its surrounding countryside.

There are three Scheduled Ancient Monuments in the city. The oldest is an Iron Age promontory fort occupied from 500 BC–200 AD. Also scheduled is Hanging Bridge on the border with Manchester, dating to the 14th century, and an underground section of the Bridgewater Canal in Swinton built in 1759.

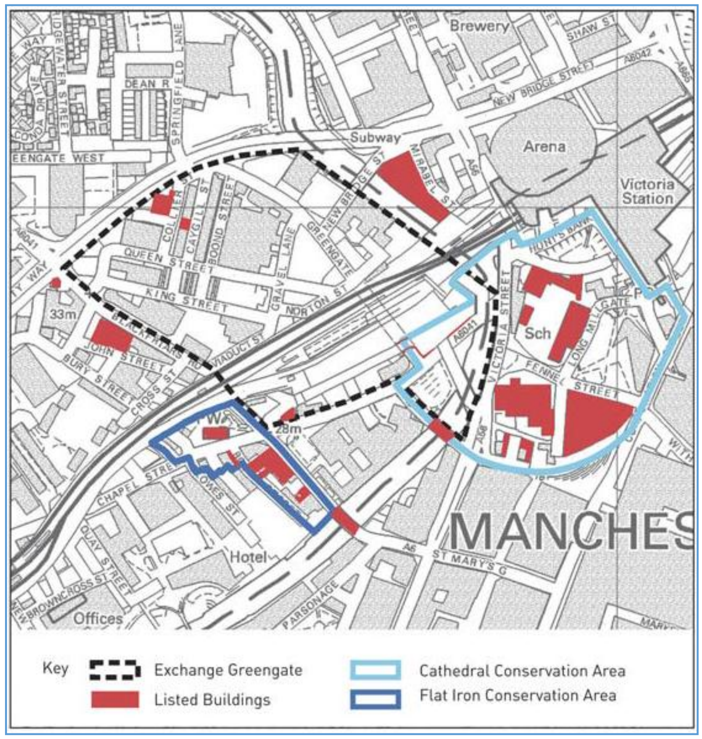


Figure 43
Conservation and listed buildings

2.3.1.1 Salford Cathedral

The Cathedral Church of St. John the Evangelist, usually known as Salford Cathedral, is a Roman Catholic cathedral in the City of Salford in Greater Manchester, England. Located on Chapel Street, Salford, not far from Manchester city centre, it is the seat of the Bishop of Salford and mother church of the Diocese of Salford. The architectural style is decorated neo-Gothic, and the Cathedral is a Grade II* listed building.

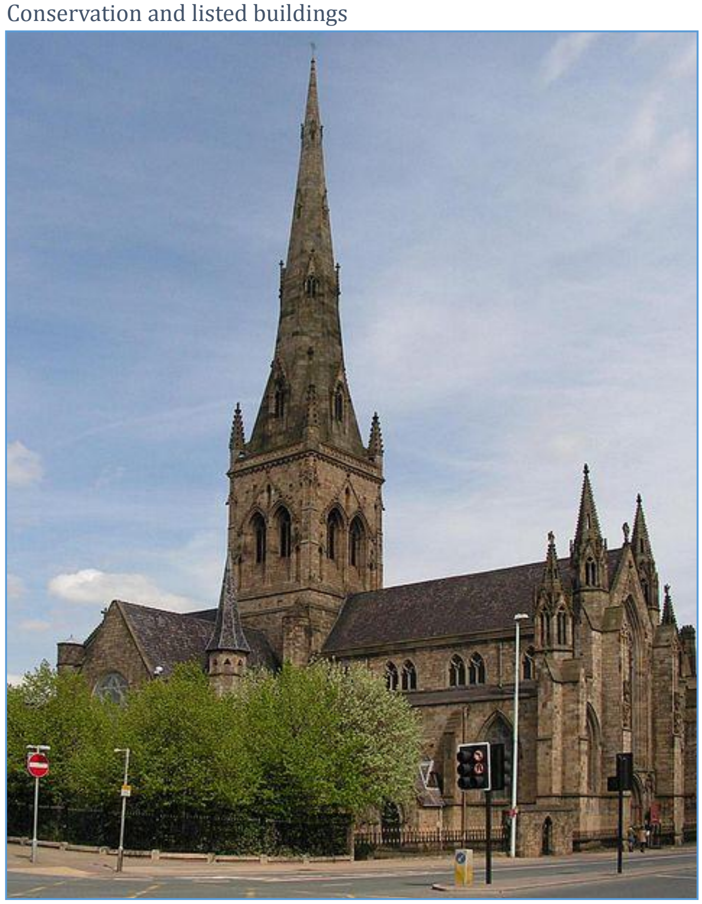


Figure 44
Salford Cathedral

2.3.1.2 St Philip's Church

St Philip's Church, Salford, is located in Wilton Place, Salford, Greater Manchester, England. It is an active Anglican parish church in the deanery of Salford, the archdeaconry of Salford, and the diocese of Manchester.

The church has been designated by English Heritage as a Grade II* listed building. It was a Commissioners' church, having received a grant towards its construction from the Church Building Commission.

In planning the church its architect Sir Robert Smirke re-used his design for St Mary's Church, Bryanston Square, Wyndham Place, London. The design of its tower was also used for St Anne's Church, Wandsworth.

In addition to church services on Sundays, the church is used for concerts, recitals and community activities.

Figure 45
St Philip's Church, Salford

2.3.1.3 Manchester Cathedral

Manchester Cathedral is a medieval church in Manchester, England seat of the Bishop of Manchester. Its official name is the Cathedral and Collegiate Church of St Mary, St Denys and St George in Manchester and is located on Victoria Street in the city centre.

Although extensively refaced, restored and extended in the Victorian period, and then again following severe bomb damage in the 20th century, the main body of the cathedral largely derives from the wardenship of James Stanley (warden 1485–1506), and is in the Perpendicular Gothic style. Stanley was also primarily responsible for commissioning the spectacular late medieval wooden furnishings, including the pulpitum, the choir stalls and the nave roof supported by angels with gilded instruments. It is one of fifteen Grade I listed buildings in Manchester.

Figure 46
Manchester Cathedral

2.3.1.4 Manchester Central Library

Manchester Central Library is a circular library south of the Town Hall Extension in Manchester, England. It is the headquarters of the Manchester Library & Information Service, which also consists of 22 other community libraries.

Designed by E. Vincent Harris, the library was constructed between 1930 and 1934, but because of its traditional neoclassical architecture it is often mistakenly thought to be much older. At its opening, one critic wrote, "This is the sort of thing which persuades one to believe in the perennial applicability of the Classical canon". The form of the building, a columned portico attached to a rotunda domed structure, is loosely derived from the Pantheon, Rome.

The library building is grade II* listed. In 2011, a three year project to renovate and refurbish the library commenced so the library will be closed until 2014.

Figure 47
A panoramic view of St Peter's Square. From the far left to right: Midland Hotel, Manchester Central Library and Manchester Town Hall extension.

2.3.1.5 Lowry Hotel

The Lowry Hotel is located by the River Irwell in Salford, Greater Manchester, England. The five star hotel is named after the artist L. S. Lowry, and although is within the boundaries of the City of Salford, it is promoted as "The Lowry Hotel, Manchester".

Figure 48
Lowry Hotel

The hotel is a member of The Leading Hotels of the World and is owned by The Rocco Forte Collection, the company of Sir Rocco Forte, son of the late hotel magnate Baron Charles Forte.

2.3.1.6 University of Salford

The University of Salford is a British public research university located in Salford, Greater Manchester, England with approximately 20,000 registered students. The main campus is about 2.4 km west of Manchester city centre, on the A6, opposite the former home of the physicist, James Prescott Joule and the Working Class Movement Library. It is situated in 240,000 m2 of parkland on the banks of the River Irwell.

Figure 49
The Peel Building

2.3.1.7 Salford Lads Club

Salford Lads Club is a boys and girls recreational club located in the Ordsall area of Salford, in Greater Manchester, England. The club was established in 1903 as a boys-only club, but today both boys and girls are welcome. The club organises recreational activities for local youth, including football, snooker, table-tennis, computer games, boxing training, dance, community meetings, exhibitions, kickboxing, excursions and Jujitsu.

Figure 50
Salford Lads Club

2.3.1.8 Ordsall Hall

Ordsall Hall is a historic house and a former stately home in Ordsall, an area of Salford, in Greater Manchester, England. It dates back more than 750 years, although the oldest surviving parts of the present hall were built in the 15th century. The most important period of Ordsall Hall's life was as the family seat of the Radclyffe family, who lived in the house for over 300 years.

Figure 51
A view of the west side of the west wing, with the Great Hall in the middle

Since its sale by the Radclyffes in 1662, the hall has been put to many uses; working men's club, school for clergy, and a radio station amongst them. The house was bought by Salford City Council in 1959, and opened to the public in 1972, as a period house and local history museum. The hall is a Grade I listed building. In 2007 it was named Small Visitor Attraction of the Year by the Northwest Regional Development Agency.

2.3.1.9 MediaCityUK

MediaCityUK is a 200-acre (81 ha) mixed-use property development site on the banks of the Manchester Ship Canal in Salford and Trafford, Greater Manchester, England. The project is being developed by Peel Media, and its principal tenants are media organisations and the University of Salford. The land occupied by the development was part of the Port of Manchester and Manchester Docks.

Figure 53
This shot (courtesy of Peel Media) shows the new development which will house the BBC, ITV and 1,500 Salford students in state-of-the-art facilities. The University will occupy the cross-hatch patterned building looking over the green space at the front.

Figure 52
MediaCityUK at night. Quay House is on the left

2.3.1.9 The Lowry

The Lowry is a theatre and gallery complex situated on Pier 8 at Salford Quays. It is named after the early 20th-century painter, L. S. Lowry, known for his paintings of industrial scenes in North West England.

Figure 54
The Lowry Arts & Entertainment Centre's main entrance

2.3.1.10 Salford Museum and Art Gallery

Salford Museum and Art Gallery, in Peel Park, opened to the public in November 1850 as the Royal Museum and Public Library, was the first "unconditionally free" public library in the United Kingdom. The gallery and museum are devoted to the history of Salford and Victorian art and architecture.

Figure 55
Salford Museum and Art Gallery

The building is located in the heart of the University of Salford, surrounded by civic and educational buildings. It plays a significant role for its relationship with the Peel building to the west and the Peel Park to the north. The building is accepted as the earliest civic building that has influenced the location of other civic buildings in the Crescent area.

2.4 Transport and access

2.4.1 Transport

The city of Salford is served by nine railway stations on four routes. Eccles and Patricroft are on the northern route of the Liverpool to Manchester Line, while Irlam, in the southwest of the borough, is on the southern route. Clifton is on the line to Bolton and Preston; Swinton, Moorside and Walkden are on the Manchester to Southport Line via Wigan; and Salford Central and Salford Crescent are served by both routes. A station at Pendleton was closed in 1998 after suffering fire damage and a loss of patronage in favour of nearby Salford Crescent, opened a few years earlier.[65] Most train services are provided by Northern Rail, although Salford Crescent is also served by First TransPennine Express as part of its TransPennine North West network.

Figure 56
Salford metro link

The Eccles line of the Manchester Metrolink runs through the City of Salford, with stations at Exchange Quay, Salford Quays,Anchorage, Harbour City, Broadway, Langworthy, Weaste, Ladywell and Eccles. The line was opened in two stages, in 1999 and 2000, as Phase 2 of the system's development.[66]

There are bus stations at Pendleton and Eccles. Buses run to destinations throughout the city, across Greater Manchester and further afield: Pendleton is served by a route to Preston, Eccles Interchange is next to the Metrolink stop.

[65] "Regulator allows closure of Pendleton station".Office of Rail Regulation. 15 December 1998.
[66] metrolink.co.uk.

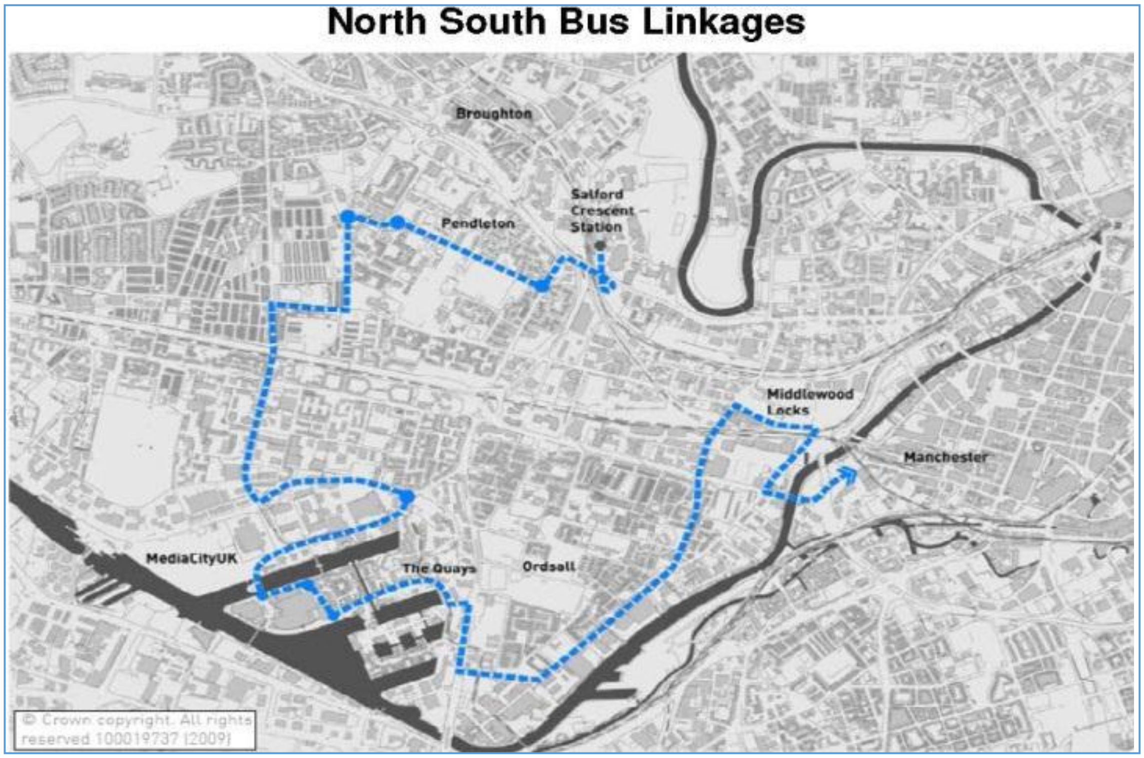


Figure 58
Bus route

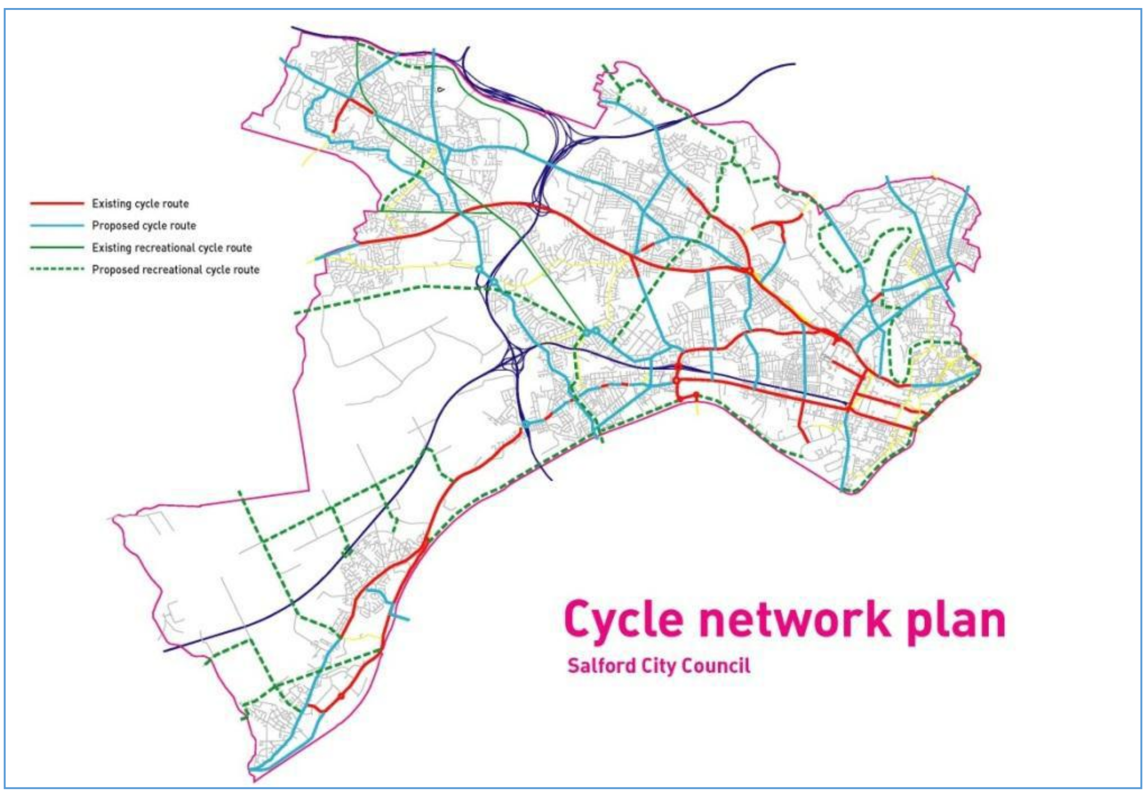


Figure 57
Cycle network plan

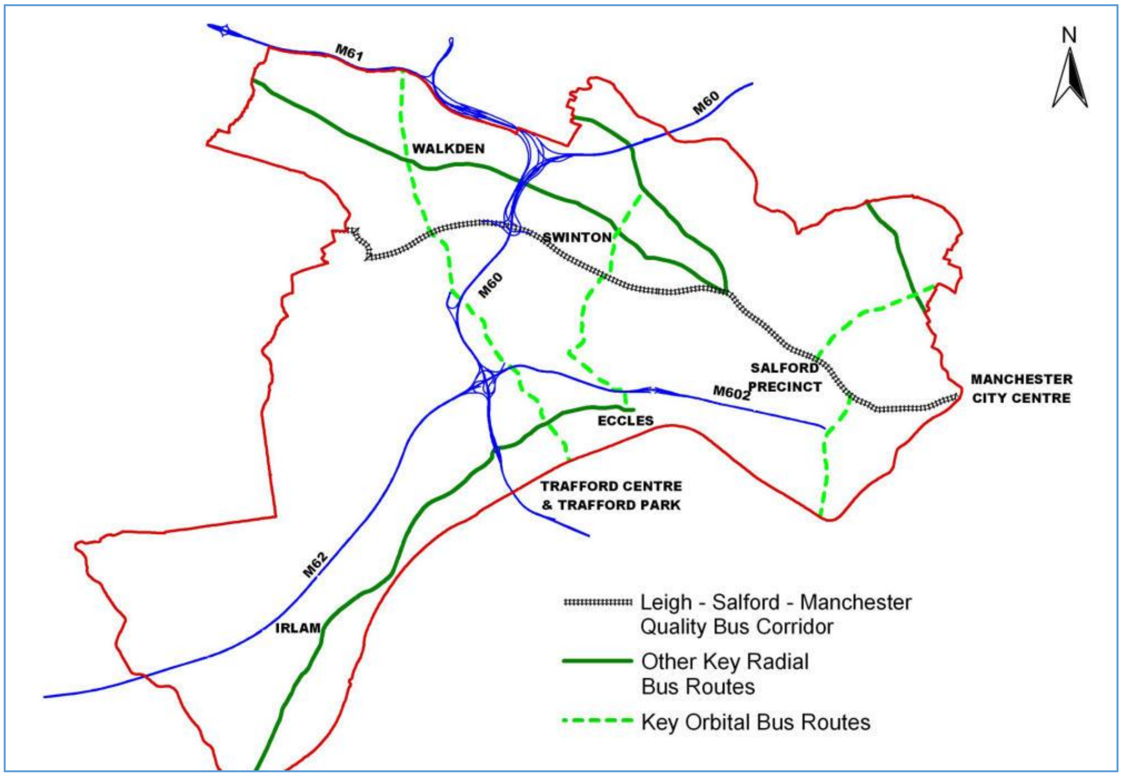


Figure 59
Salford City bus routes

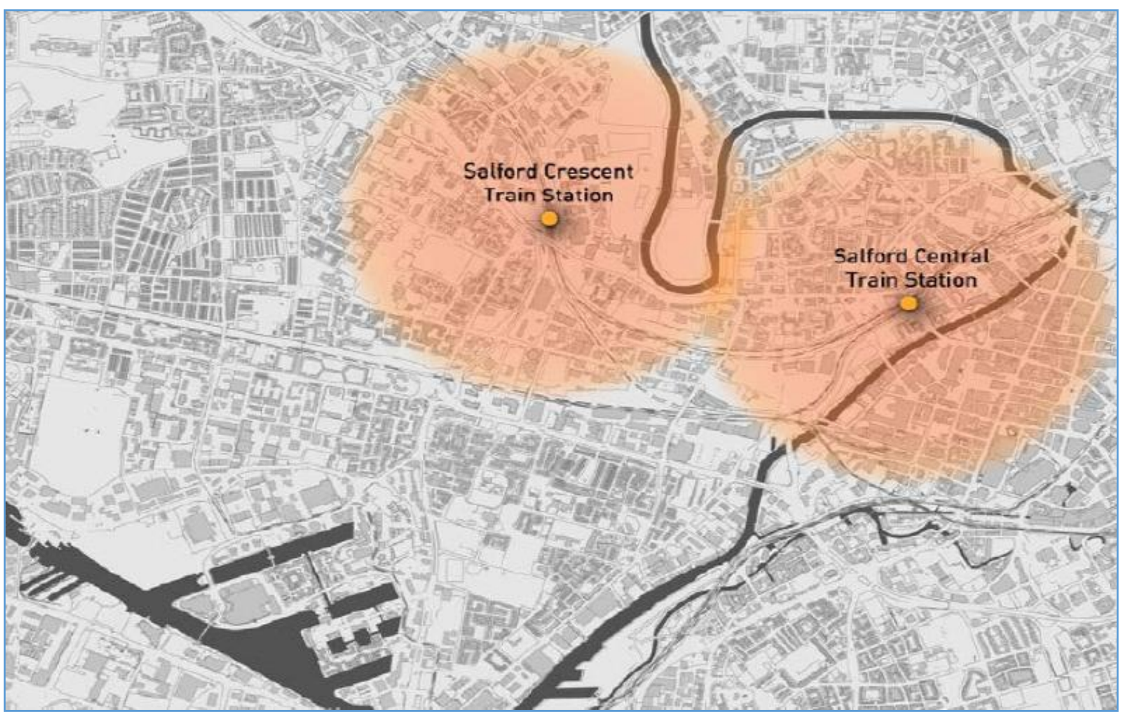


Figure 60
Salford railway stations

2.4.2 Access to services in Salford

In summary, residents in Salford generally have good access via public transport to the key services/facilities identified below:

Service/Facility	Time to access service/facility	% of residents accessing the service/facility within the time specified on the left (2010/11)
General Practitioner (GP)	Within 15 minutes	99.25%
Hospital	Within 30 minutes	86.80%
Primary Schools	Within 15 minutes	99.57%
Secondary Schools	Within 20 minutes	94.68%
Further Education	Within 30 minutes	96.69%
Employment	Within 20 minutes	99.90%
Major retail centre	Within 15 minutes	93.22%
MediaCityUK	Within 30 minutes	27.89% (2011)
Local equipped area for play	Within 5 minutes	43.43% (2009/10)
Neighbourhood equipped play area	Within 15 minutes	93.27% (2009/10)
Neighbourhood Parks	Within 15 minutes	99.00% (2009/10)
District Park	Within 40 minutes	99.98% (2009/10)
Local Semi-natural greenspace	Within 5 minutes	46.22% (2009/10)
Strategic Semi-natural greenspace	Within 25 minutes	91.99% (2009/10)

Figure 61
Access to services in Salford

2.5 Greengate Analysis

2.5.1 Land Use

Figure 62
Land Use

site

Residential

industrial

Commercial & leisure

Public spaces

2.5.2 Density

2.5.2.1 Full and Empty

Figure 63
Density 1

site

Built spaces

Open spaces

Roads and streets

2.5.2.2 New development and To be demolished

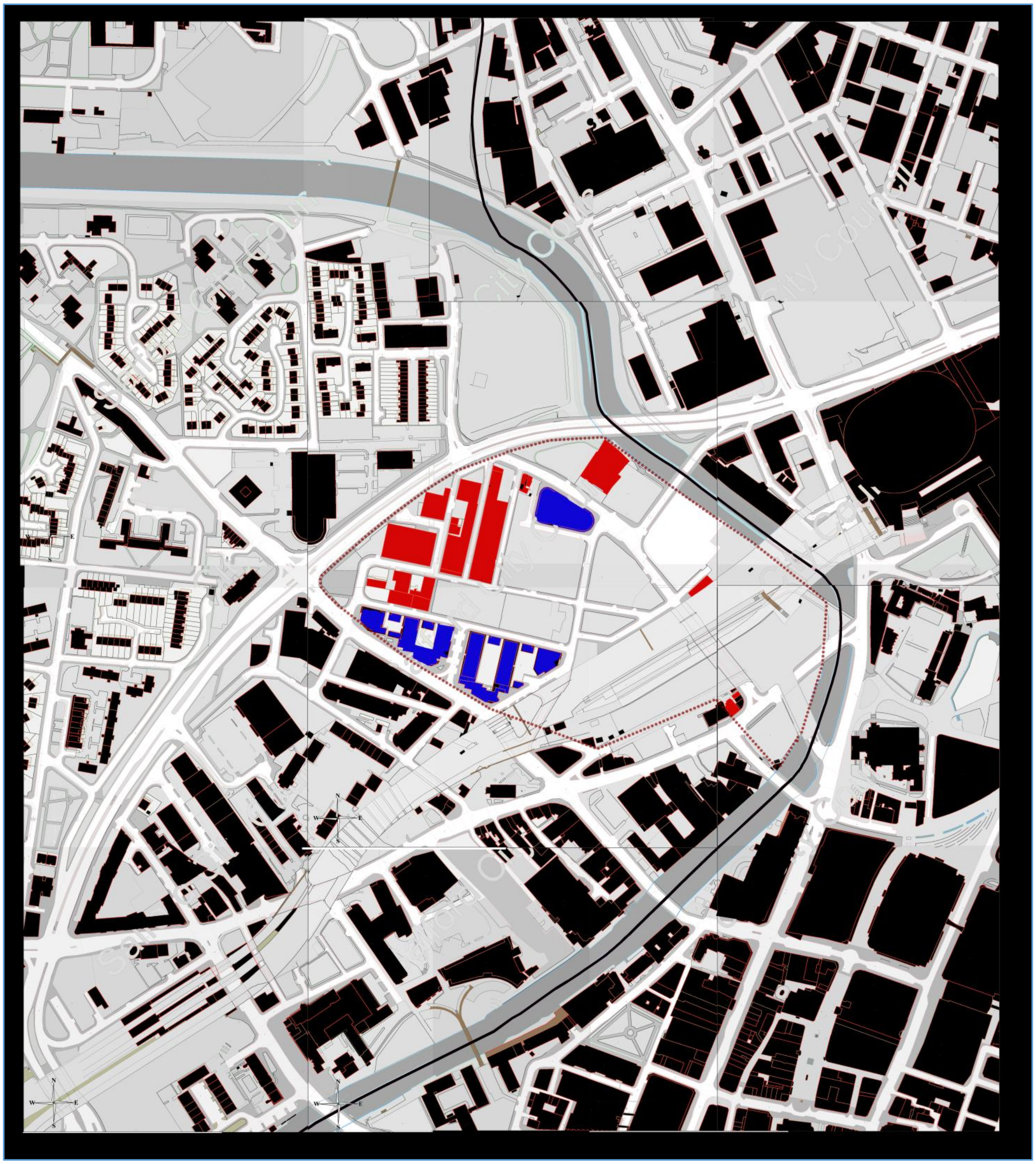


Figure 64
New development and To be demolished

site

New development

To be Demolished

2.5.2.2 New development and Open space

Figure 65
New development and Open space

site

New development

Open spaces

2.5.3 Greenery

2.5.3.1 Green and built spaces

Figure 66
Greenery

site

Built spaces

Green spaces

2.5.3.2 Green spaces and city spots

Figure 67
Green spaces and city spots

site
Train station
Cathedral
commercial
Public Green spaces
Cultural

2.5.4 Mobility

2.5.4.1 Roads Morphology

Figure 68
Roads Morphology

site

Built spaces

Street pattern

2.5.4.2 Main Streets and Secondary Connections

Figure 69
Main streets and secondary connections

site

Trinity way

Blackfriars road

Chapel street

Scondary connections

2.5.4.3 Bus Routes

Figure 70
Bus Routes

site
Bus routes
major stops
Other stops

2.5.4.4 Metroshuttle

Figure 71 Metroshuttles are free buses linking the main rail stations, car parks, shopping areas and businesses in Manchester city centre.

site

Line 1 and stops

Line 2 and stops

Line 3 and stops

2.5.4.5 Walking paths

Figure 72
Walking paths, as it is shown on the map above path number one has the length of 500 meters and path number two has the length of 550 meters.

site
Main pedestrian axis
Train station
Cathedral
commercial
Public Green spaces
Cultural

2.5.4.6 Cycling routes

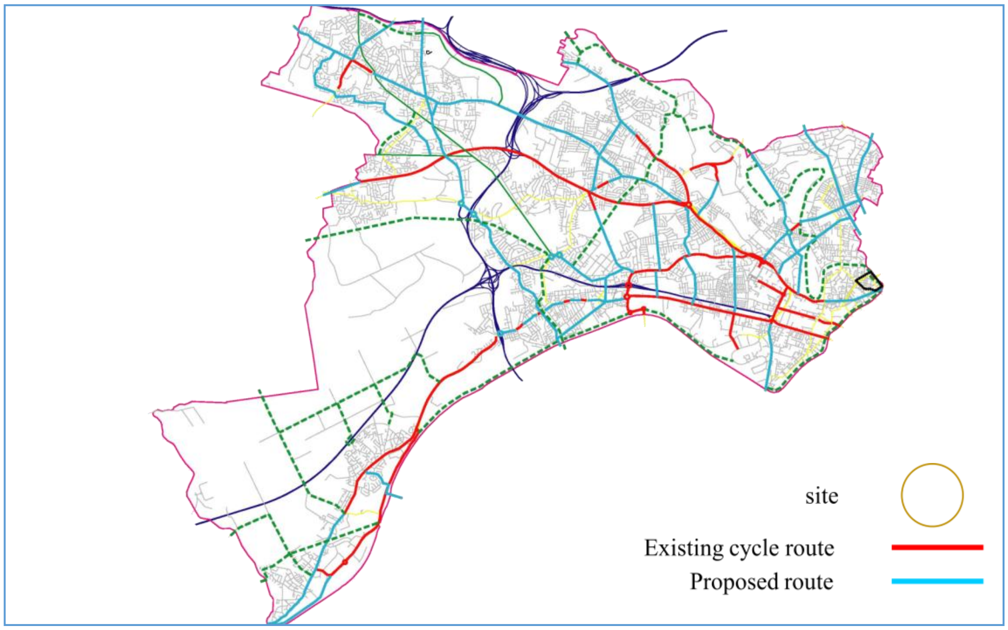


Figure 73
Cycling routes, existing and proposed

2.5.4.7 Road and Railway improvements

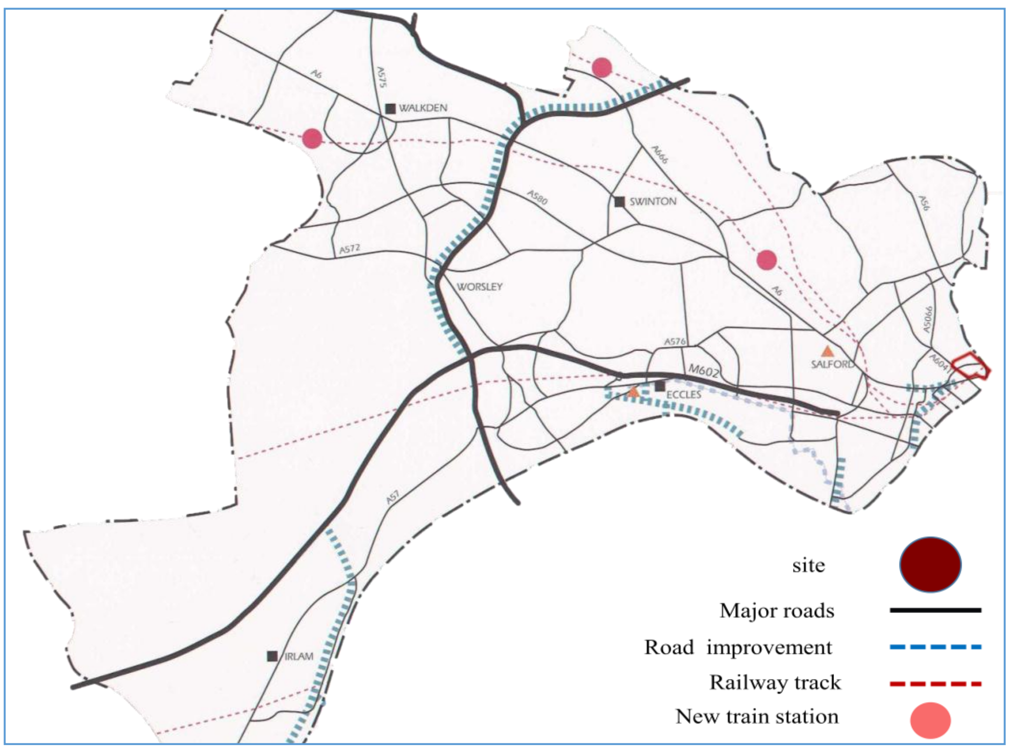
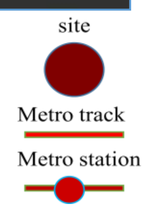


Figure 74
Roads and railway tracks improvements

2.5.4.8 Accessibility Metro

Figure 75
Metro Accessibility



2.5.5 Barriers

The main barriers in Greengate are the rail track and the River Irwell.

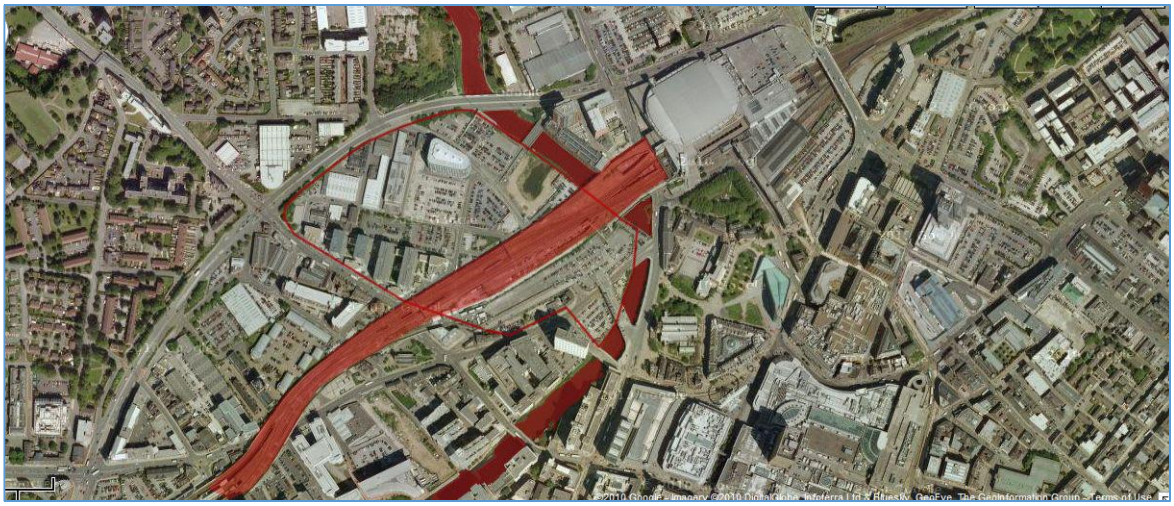


Figure 76
Barriers in Greengate

2.5.6 Connection over the barriers

Connections over the barriers in greengate are obtained by tunnels under the train track and bridges over the River Irwell.

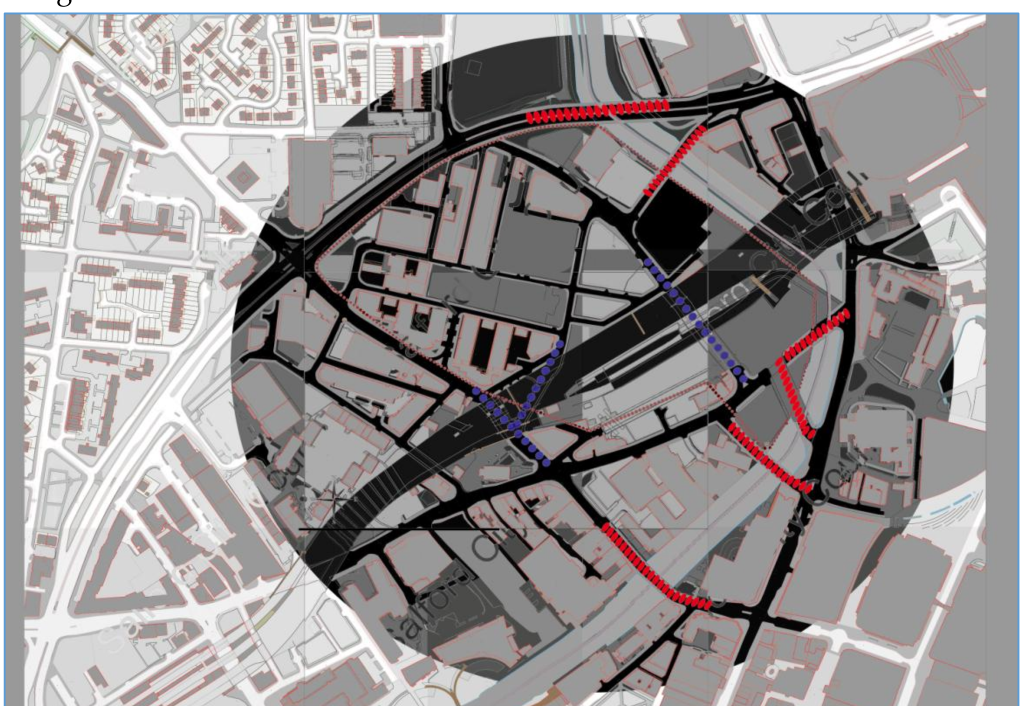


Figure 77
Connection over the barriers

2.5.6.1 River Bridges

There are six bridges working as a connection over the River Irwell, connecting the Greengate to the other side of the river. The river does the border role between the city of Salford and the cities around so these bridges are doing the main connection part on the eastern side of the city.

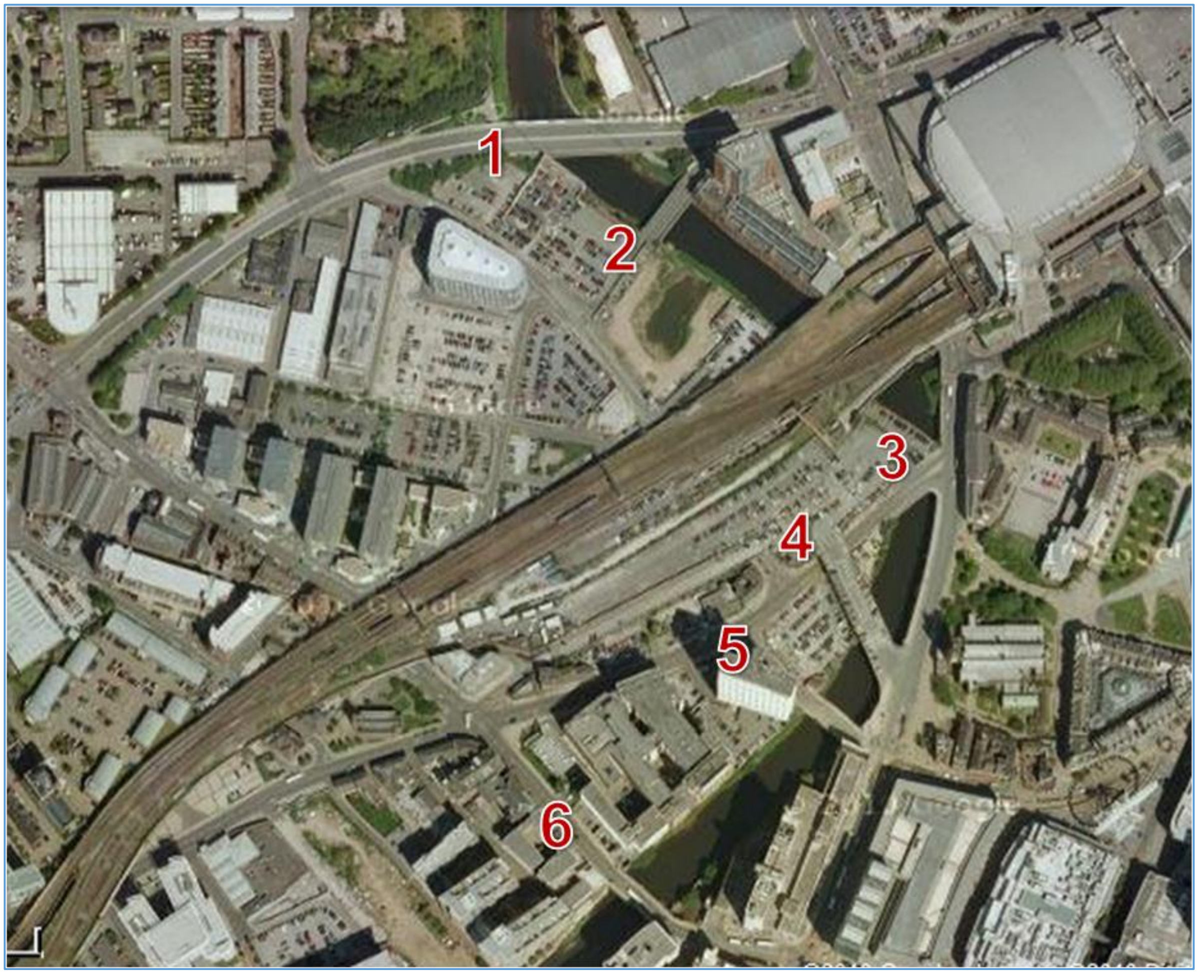


Figure 78
River bridges

1- Trinity way

2- New Bridge St.

3- Chappel St.

4- Cathedral Approach

5- Victoria bridge St.

6- Blackfriars road

2.5.6.1.1 Trinity Way Bridge

2.5.6.1.2 New Bridge St.

Figure 79
The Trinity Way Bridge and The New Bridge St. locality

As it is shown in the figure below The Trinity Way Bridge and New Bridge St. are performing a very important part to connect the station, commercial and the public car park.

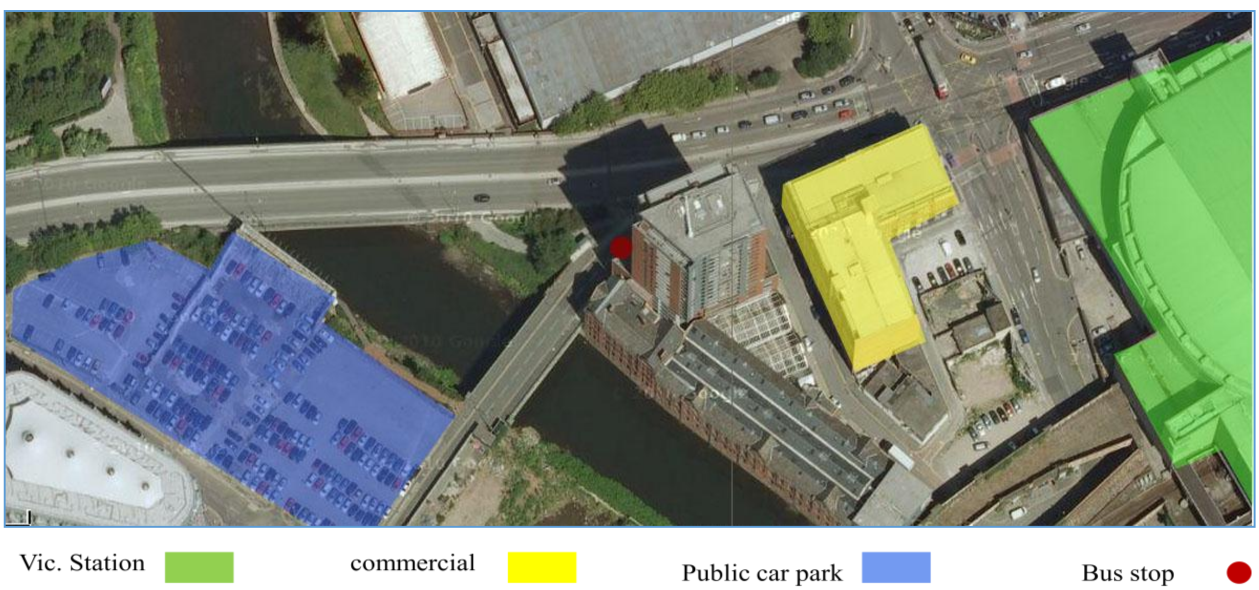


Figure 80
The Trinity Way Bridge and New Bridge St. vicinity to city spots

2.5.6.1.3 Chapel St. Bridge

Figure 81
The Chapel Street Bridge locality.

As it is shown in the figure below The Chapel Street Bridge is a very important connection between the leisure-cultural part, educational part and the public car park.

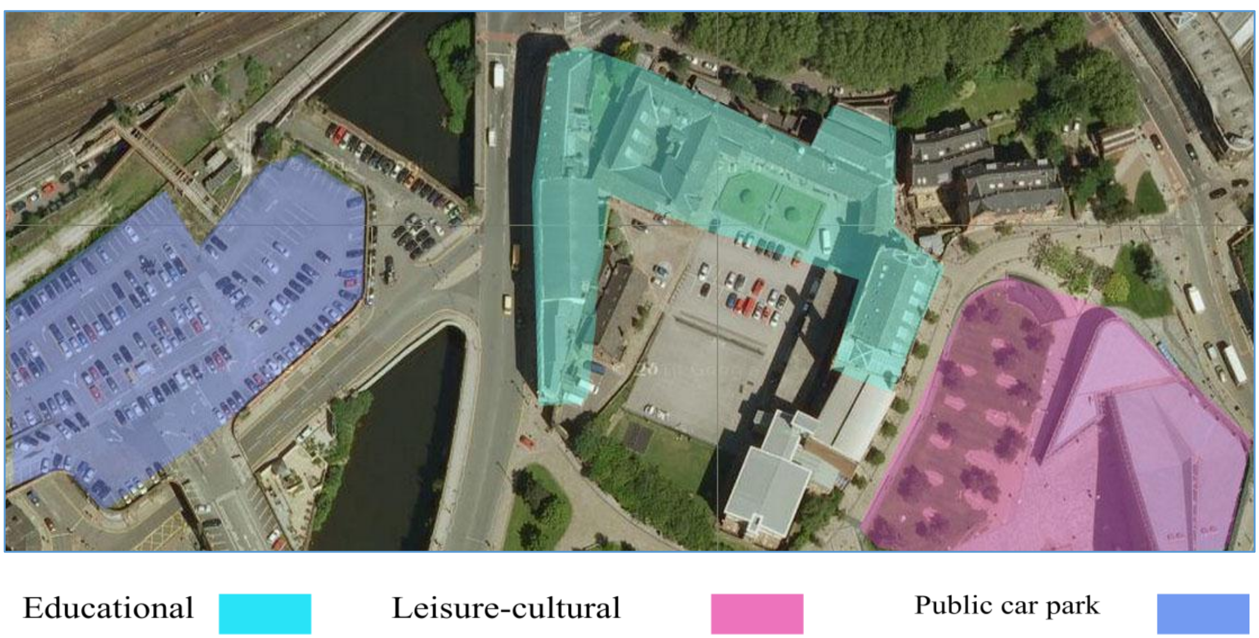


Figure 82
The Chapel Street Bridge vicinity to city spots

2.5.6.1.4 Cathedral Approach Bridge

2.5.6.1.5 Victoria Bridge Street

Figure 83
The Cathedral Approach Bridge and the Victoria Bridge st. locality

As it is shown in the figure below The Cathedral Approach Bridge and The Victoria Bridge Street are performing a very important role on making the connection between the Manchester Cathedral, the hotel, shopping center and the public car park.

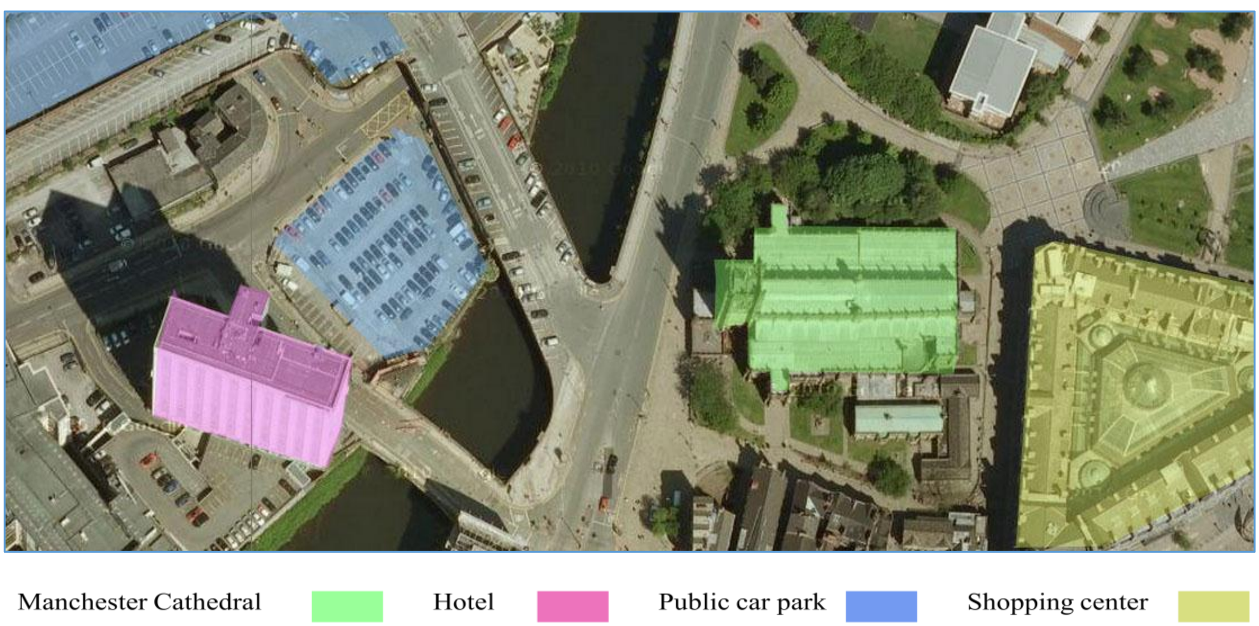


Figure 84
The Cathedral Approach Bridge and the Victoria Bridge Street vicinity to city spots

2.5.6.1.6 Blackfriars Road

Figure 85
Blackfriars Road locality

The Blackfriars Road Bridge performs a very important connection role between Salford and Manchester City. The Blackfriars Road is Entering Salford as Great Clowest street from north and after passing through the city is going inside the Manchester City as the Market street.

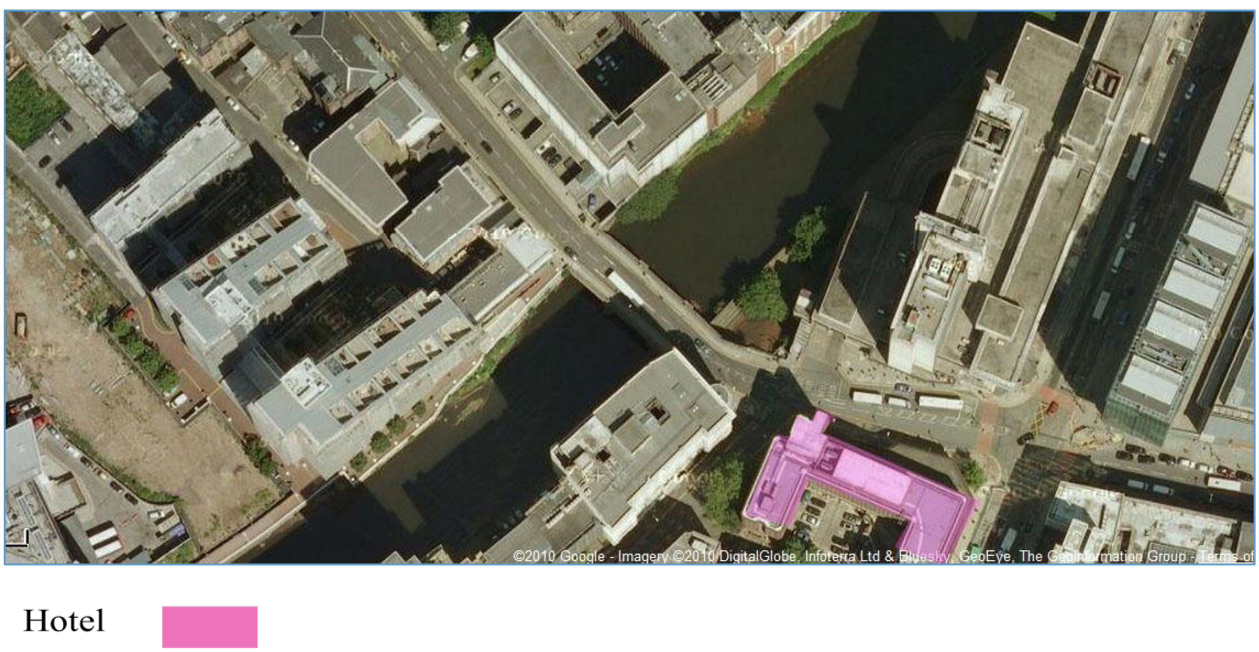


Figure 86
Blackfriars Road vicinity to city spots

2.5.6.2 Greengate Tunnel :

This tunnel is located on an important road in our site . The figure below shows how it can be the passage way pedestrian and cars to access important areas on the Manchester side of the river.

Figure 87 tunnel connections

As marked by the lines above, the improvement of these paths for pedestrian access, and providing a green and pleasant walking experience, can encourage the current and future habitants of future developments to take pedestrian and bike paths instead of use of car.

Figure 88 tunnel entrance

In the image above we see the current view of the entrance of the tunnel. As it is even obvious in the image the dark interior of the tunnel may make it even kind of dangerous to use at night and less crowded hours of the day. Also revitalizing lots of commercial spaces under the train track, as seen in the image, can help vitalizing the neighborhood, and can satisfy the needs of new and future residences of the Greengate area.

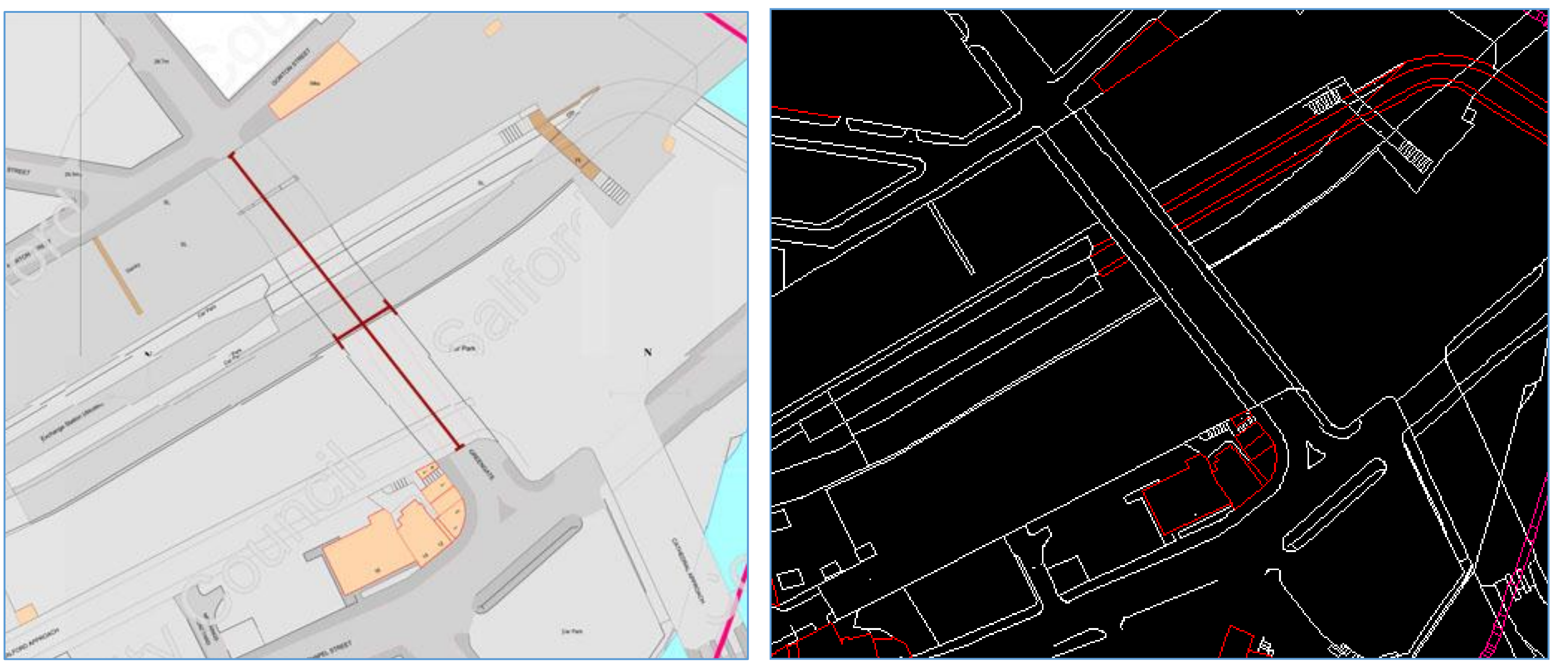


Figure 89 tunnel drawings

As marked in the image above with red lines, the lengths of the tunnel is up to 100 meters and has a width of almost 16 meters.

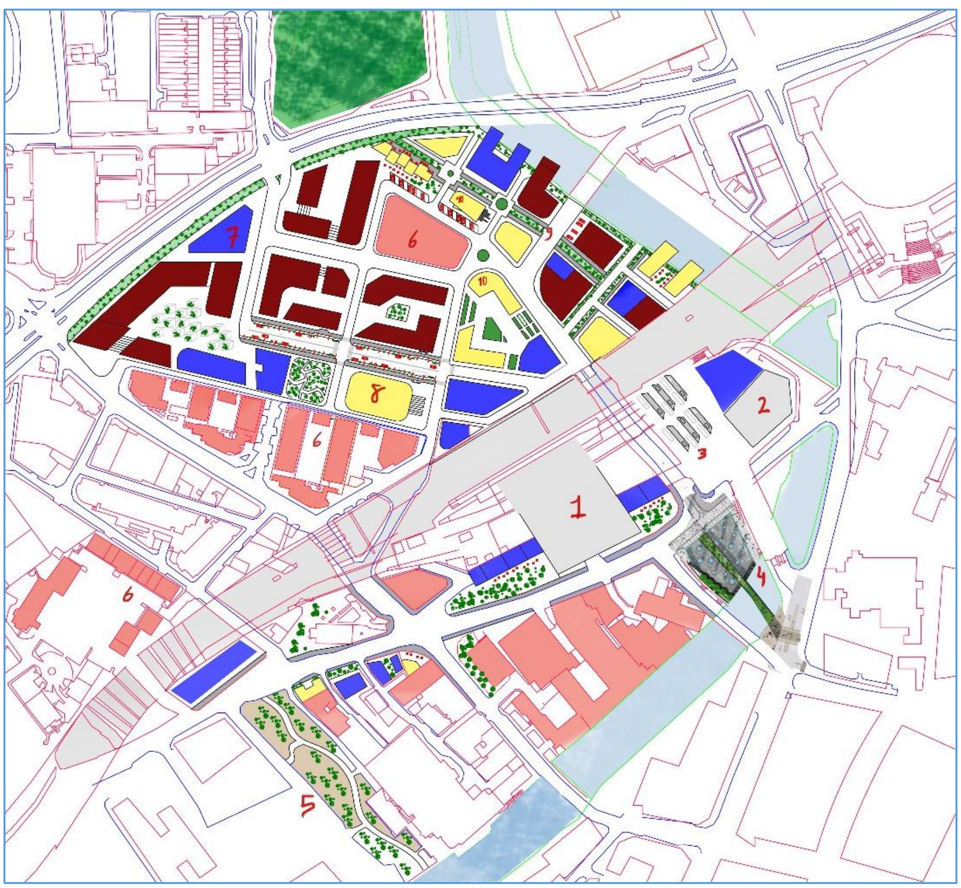
2.6 Urban Cocept Design

In this section we will present our strategies and a conceptual design for future urban development in Greengate areas. This concept will be based on the studies we have done and analysis presented before, to determine the needs and potentials of the zone for new functions to adopt. Another guideline for the concept design was the considerations by competition requirements and municipality plans or limitations.

We started by some primary sketches to introduce new functions for empty areas or with unimportant buildings, later we study better such a layout and try to define better the improvements in the neighborhood and a manual for future constructions.

2.6.1 Primary concept plan

Here we see a sketch of an early study where we have located new functions as we need determined by our studies, and a layout that may adopt our urban strategies. In the new plan layout one important consideration was keeping the current tracks of streets and walkways, the ones analyzed above , as much as possible, as the municipality indicates they are well defined, even if the building inside the path borders is to be demolished. .



1- new transport hub 2-multifloor parking
3- Urban Bus Station
4-New Pedestrian Bridge
5- Neew Park
6- Residential Complex
7- gas Station 8-sport pitch
9-green parh 10- art gallery

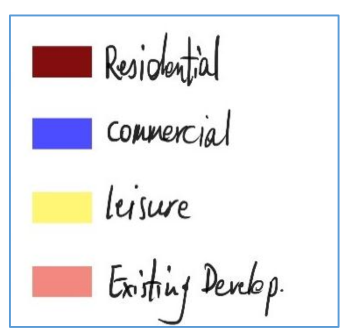


Figure 90 plan sketch

our primary concept plan contains all the functions we had found necessary by studies done and presented before. We will now see some main strategies according to which we further detail some parts of the zone.

2.6.2 Urban Design Strategies

Greenery: in the image below we can see the existing greenery around the site and the ones proposed by us according to the concept plan sketch.

Figure 91 Greenary Concept

Green Path : Green pedestrian path is an important strategy for the development of Greengate area. We propose a kind of green belt around the site, which extend in large pedestrian areas with many leisure facilities on north side of the site, which the path shall connect some major green areas in site together and in the end, with new pedestrian bridge will bring us to the other side of river, to major public sites.

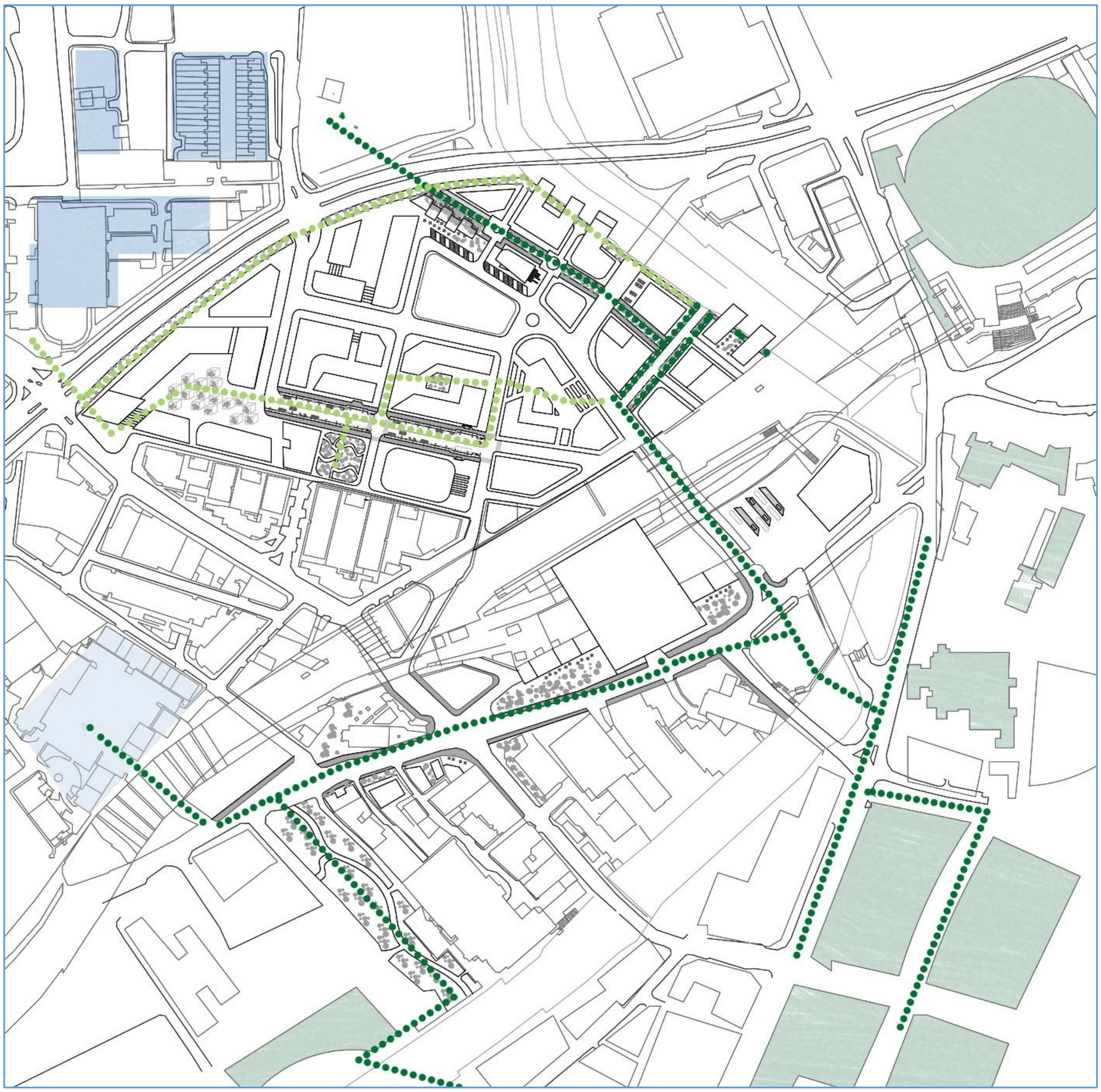


Figure 92 Green Path

Car Routes : car access improvement into the site , in through it for access to important places aroun greengate area, was another important strategy in forming the urban area. In the figure below these routes are marked by red and blue as primary and secondary and are with few modification on how the footprint of marcipiedi around the site.

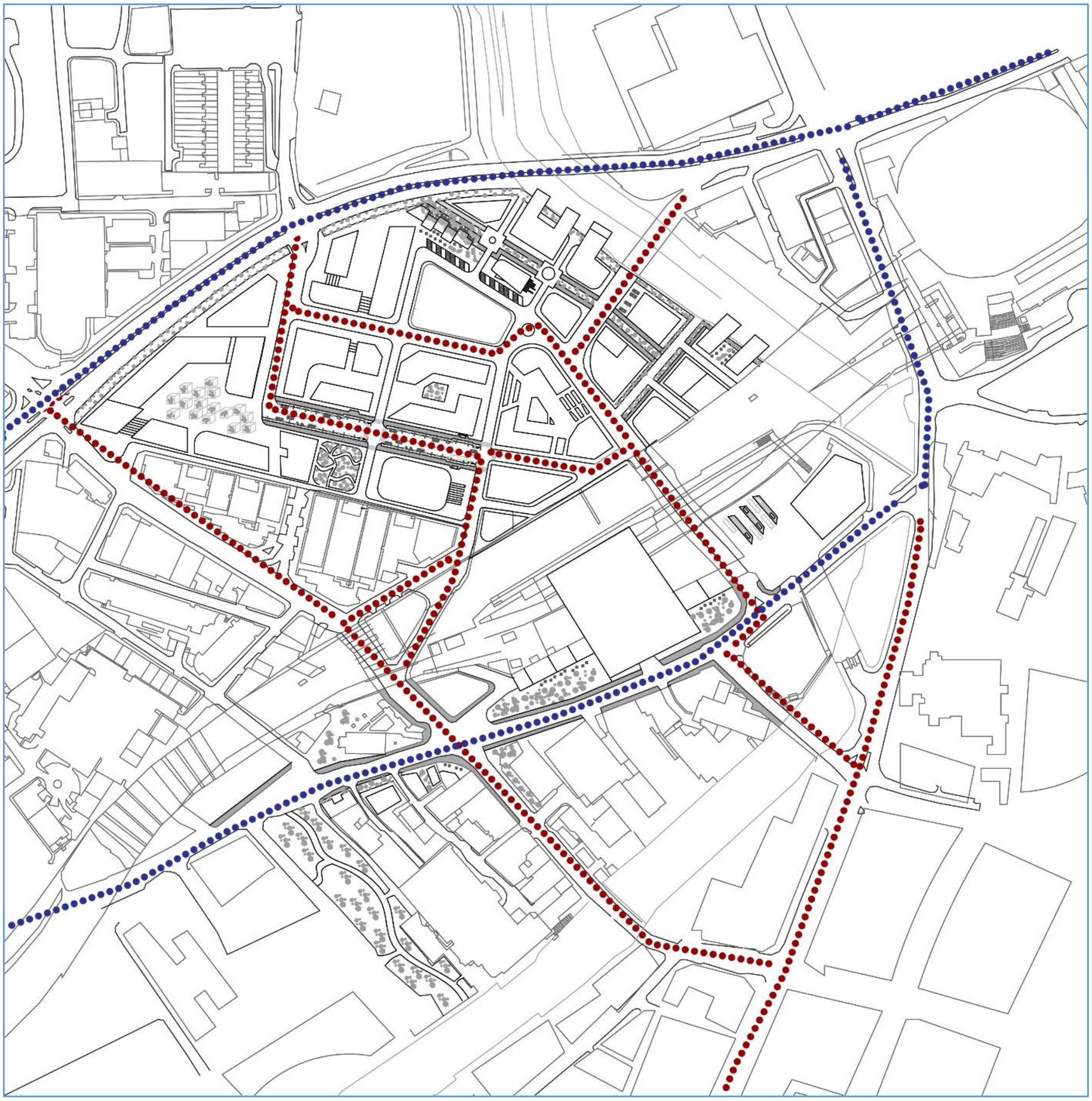
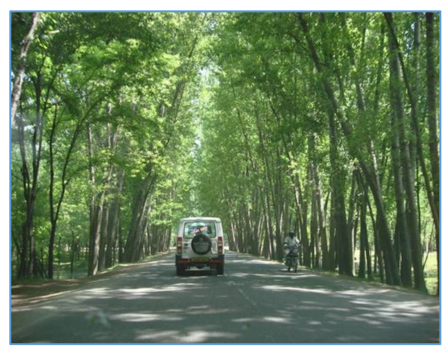


Figure 93 Car Route

Greengate Tunnel and Green Bridge : this part of the green pedestarian path is a main aspect of it as we try to improve the conditions of greengate tunnel seen before, for better pedestarian acess and along its end we will have a buffer zone before a newly introduced pedestarian bridge , to pass Irwell river and to arrive to manchester side.

Figure 94 sketch of green path



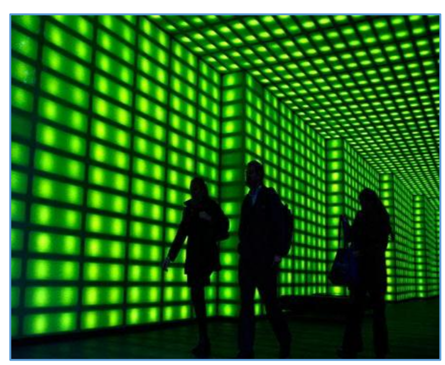


Figure 95 green tunnel

With some good lighting and interior design work inside the tunnel, we can persuade people to path through it, as it is a very good access to Manchester public spaces.
After the tunnel we will have the buffer zone which can be a meeting point, stop and cause point with tired pedestrians or joggers, right before a newly designed bridge dedicated to pedestrian access, unlike any other bridge connecting green gate to Manchester which are all for car access.

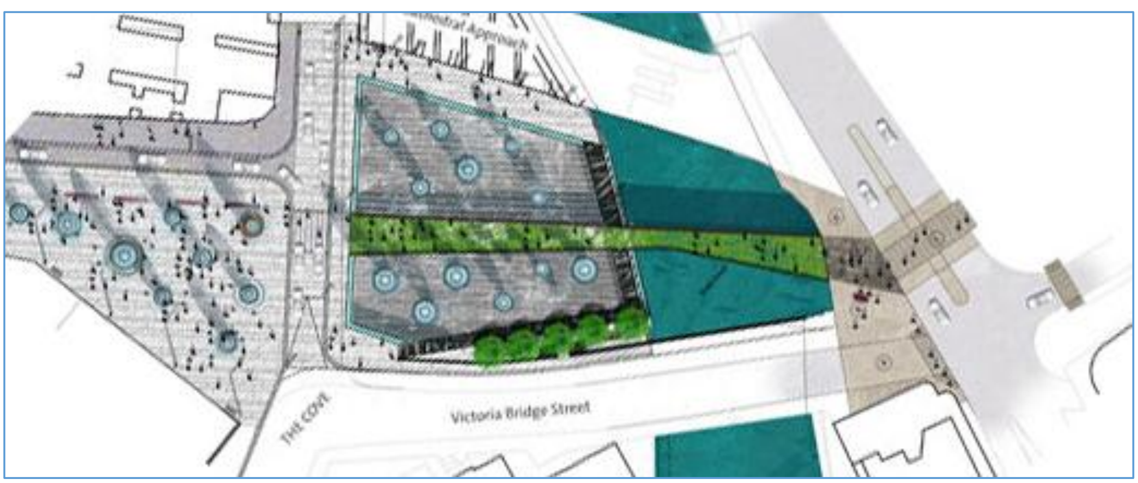
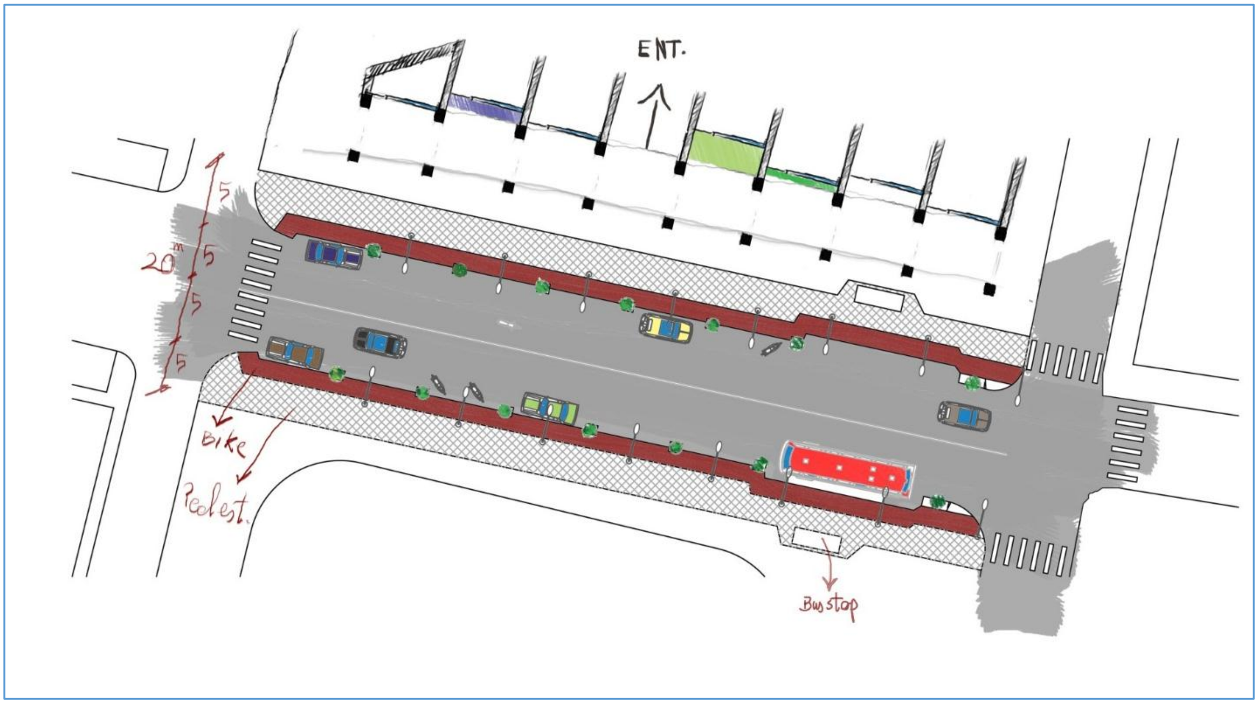


Figure 96 Green Tunnel and Bridge

Street structure : we had seen some main streets with a layout like the figure below. The section of street sees these layers from the envelope of the buildings: base on edge of the buildings, pedastarian way, bycicle path and the main street which sees flower boxes, parkings and bus stops. Such a layout of street may work with different forms of surrounding buildings. The following figures show such relations:



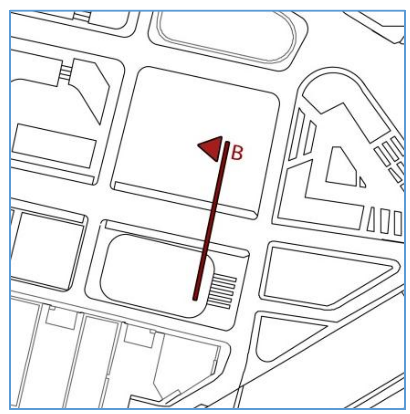


Figure 97 street section

Possible Architecture of Blocks: as a large part of the urban development is dedicated to residential buildings which in particular for the House4Life competition 120 units are necessary. So we performed some sketches to see within the urban structure of Grengate, what possibilities of buildings can be. These sketches show possible layouts in plans to continue urban flow also under the blocks, and their possible forms and volumes.

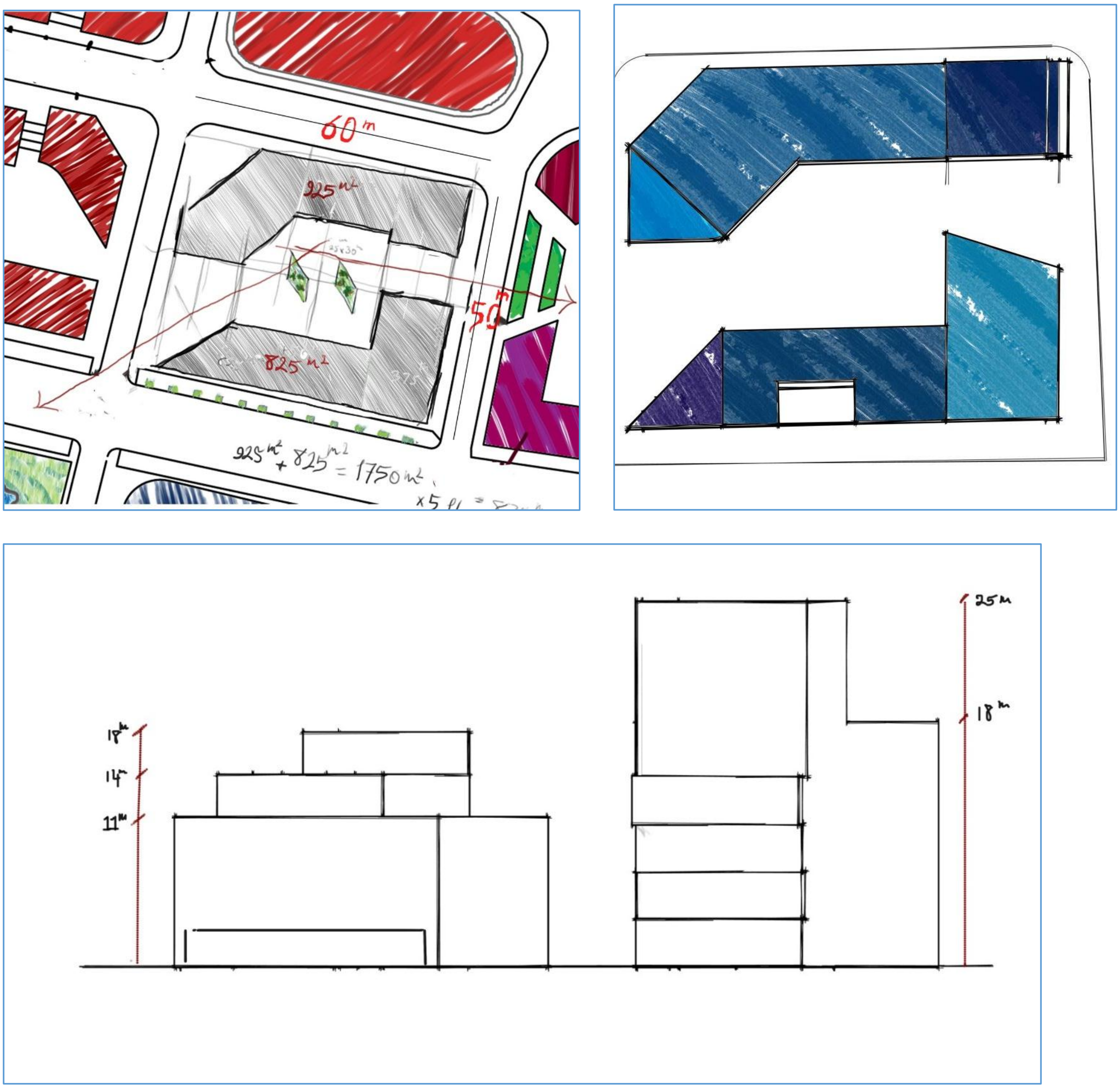
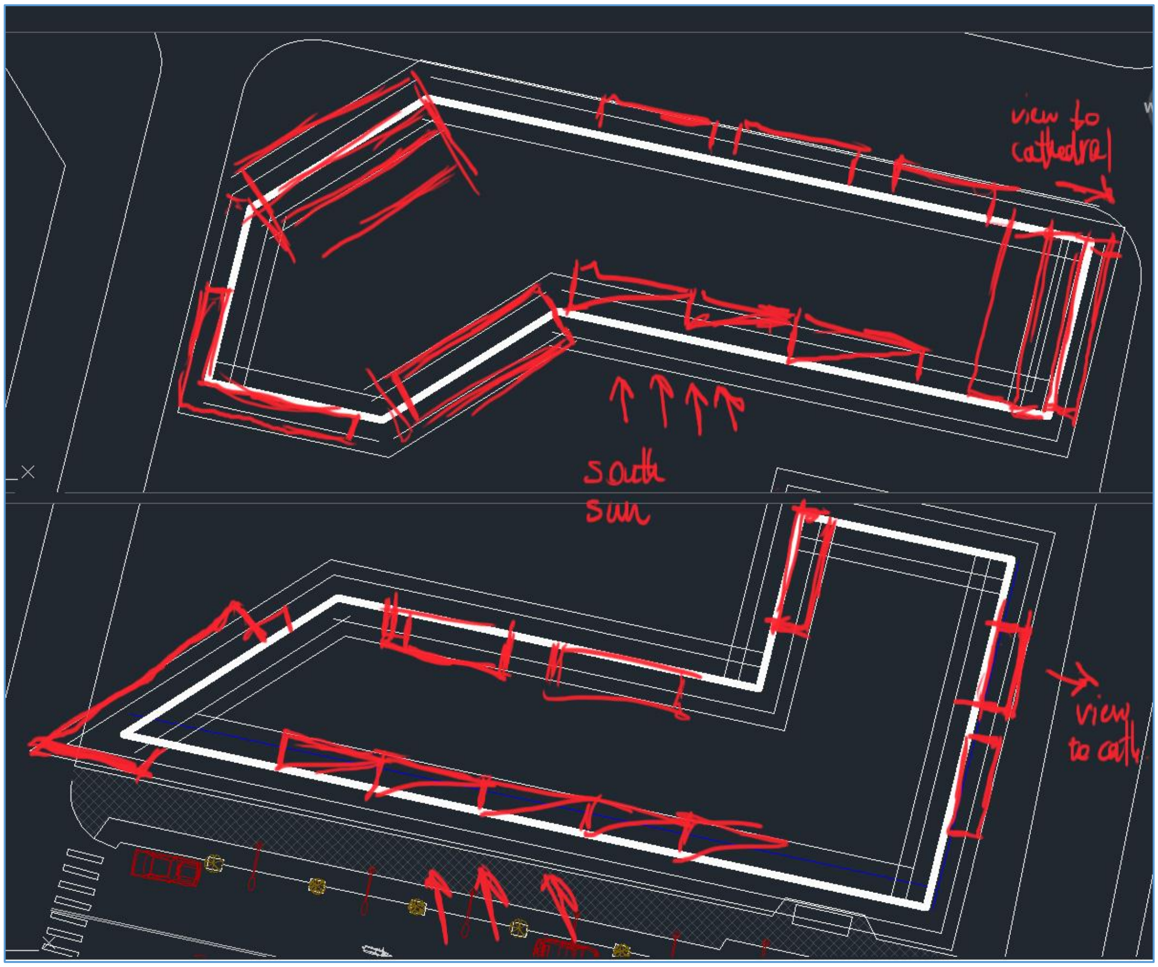
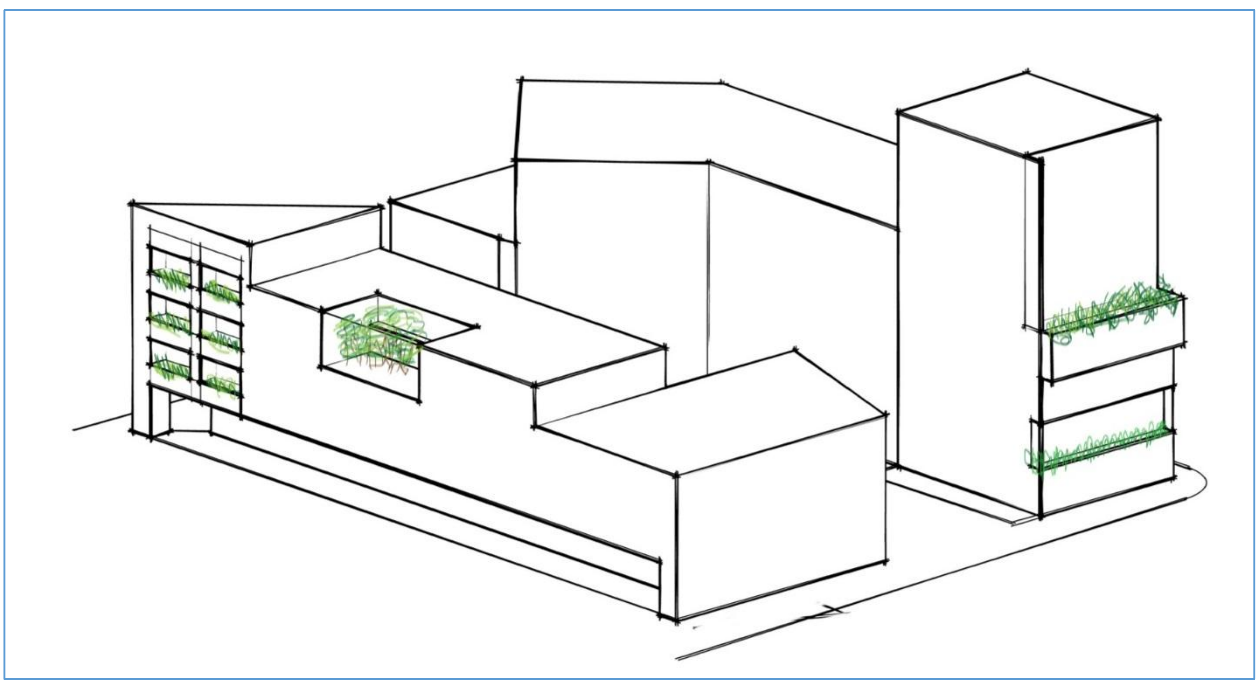


Figure 98 Buildings in urban context


view to cathedral
south sun
view to cath



Here we see some sections of the importan areas inside the concept plan.

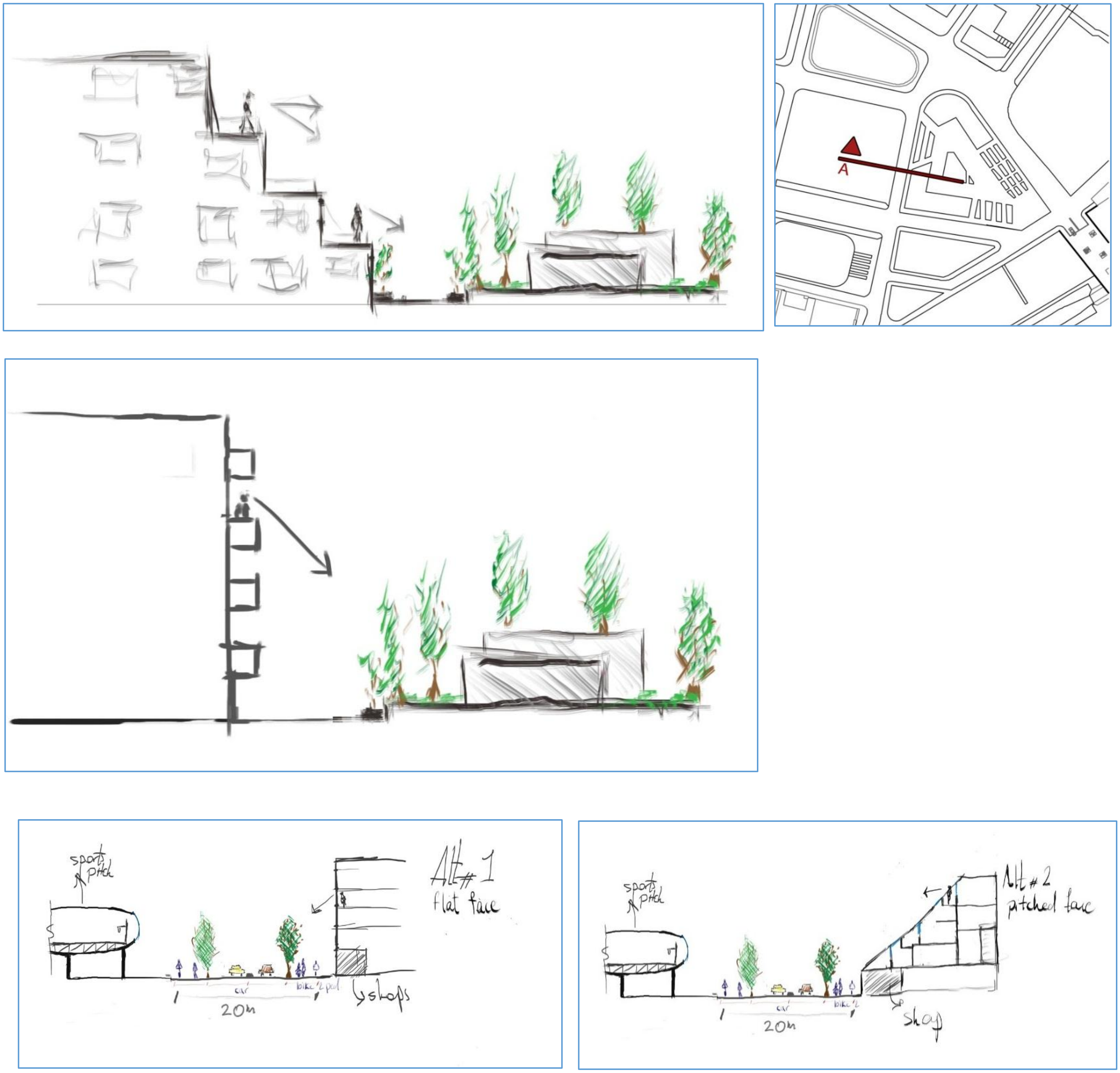


Figure 99 Sketches on Building configurations in site

2.6.2 Concept Plan :

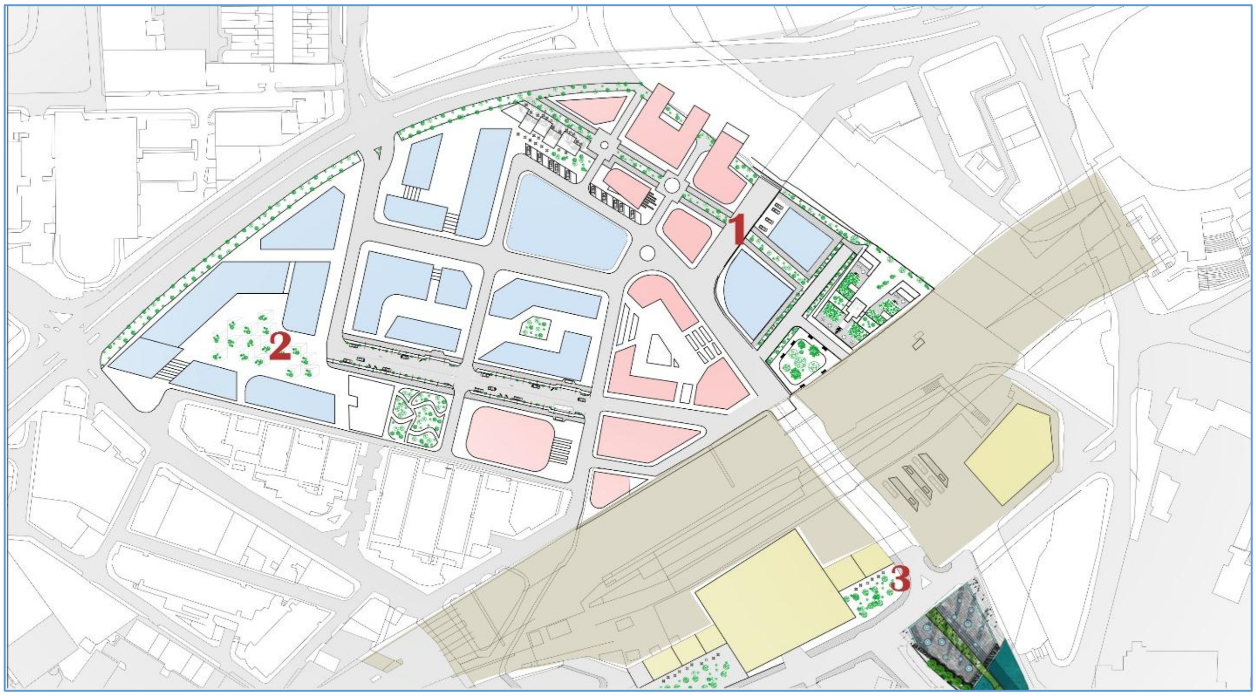


Figure 100 Concept Plan

Blue: Residential Red: Leisure,Cultural,Sport Yellow : Transport Hub

In the proposed layout for new urban developments in greengate area, we see 3 major zones of development.

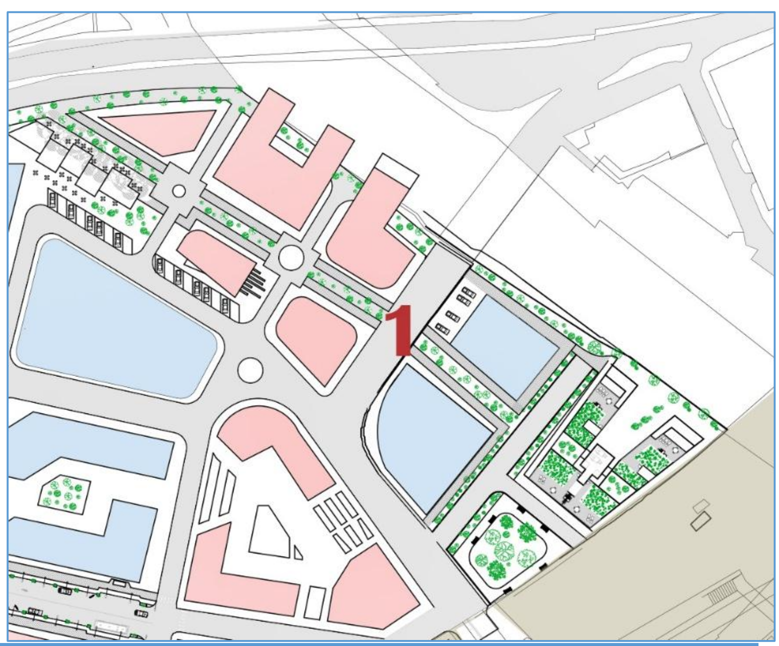


Figure 101 Zone 1

In **zone 1** we have the main pedestrian path and axis in the area. The wide path is filled with greenery and along it the car access is limited. on sides of the path many leisure facilities such as bar and restaurants are considered to help vitalizing this path that in the end does part of the axis that passes from tunnel to Manchester. This zone contains sites that are suitable for the architectural development of the thesis project. In the next section we will study some sites to determine for the architectural desgn. This zone is mainly a mixed of residences and leisure functions.

by adding urban furniture and a well defined path which is not disturbed by cars, we can help make the zone a vital and a new point of attraction in for neighbours in Manchester and greengate area. The ground level of all the building are dedicated to public functions.

Figure 102 view of green path

in **zone 2** we have the main residential blocks of the new urban developments. In vicinity we have also a s,all green area, and a sport peach. As the high number of residences, this zone has also the main car street and has the largest ones.
the blocks are designed in a way the create Piazza like spaces inside tehm in the ground level.

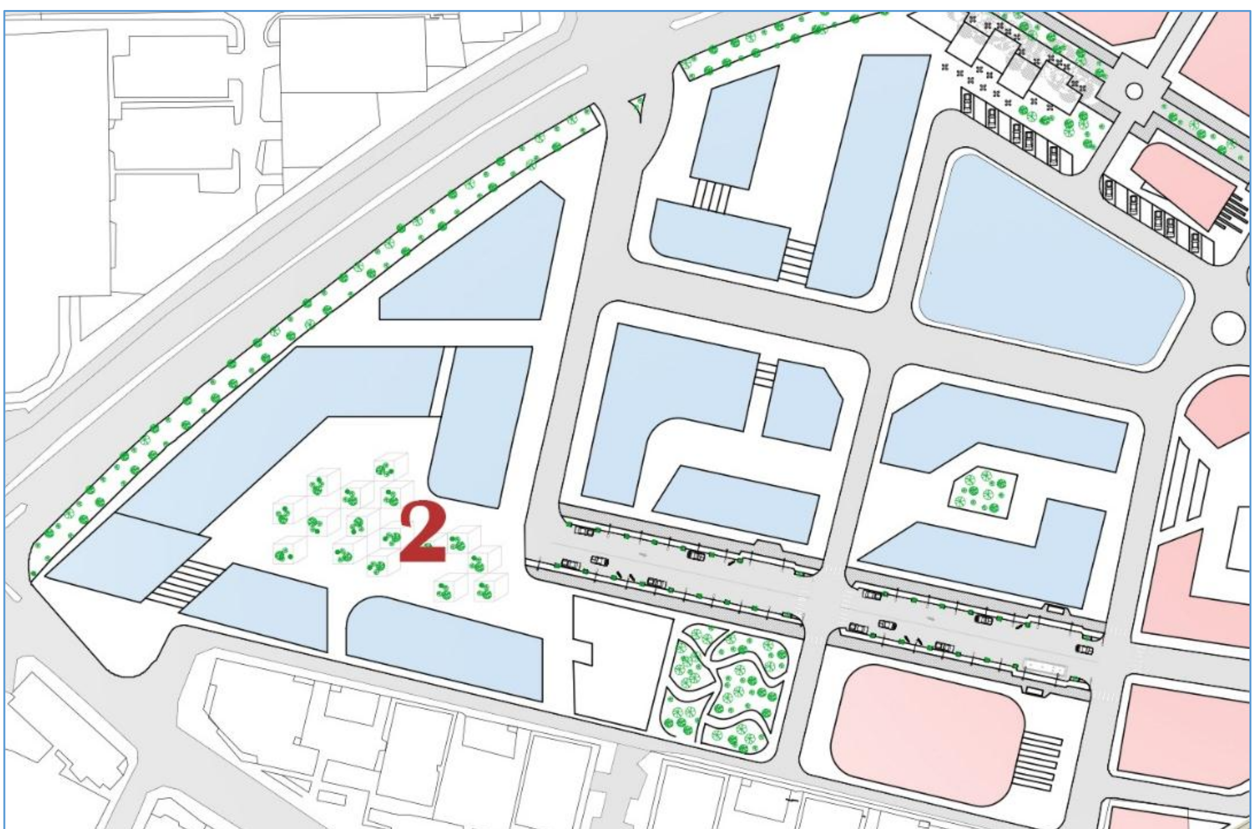


Figure 103 Zone 2

Zone 3 is part of urban development in Greengate , as it has the critical train track and is located on the border of Irwell river ,before entering the Manchester public spaces area. As seen in the strategies before, we must improve the quality of Greengate tunnel as a part of out green path. On the exit of tunnel a green buffer zone is defined where a new pedestrian bridge will be inserted between the two car use bridges, to complete our green path strategy , which starts from the angle of the residential blocks in zone 2, takes up the belt and enters the green path.

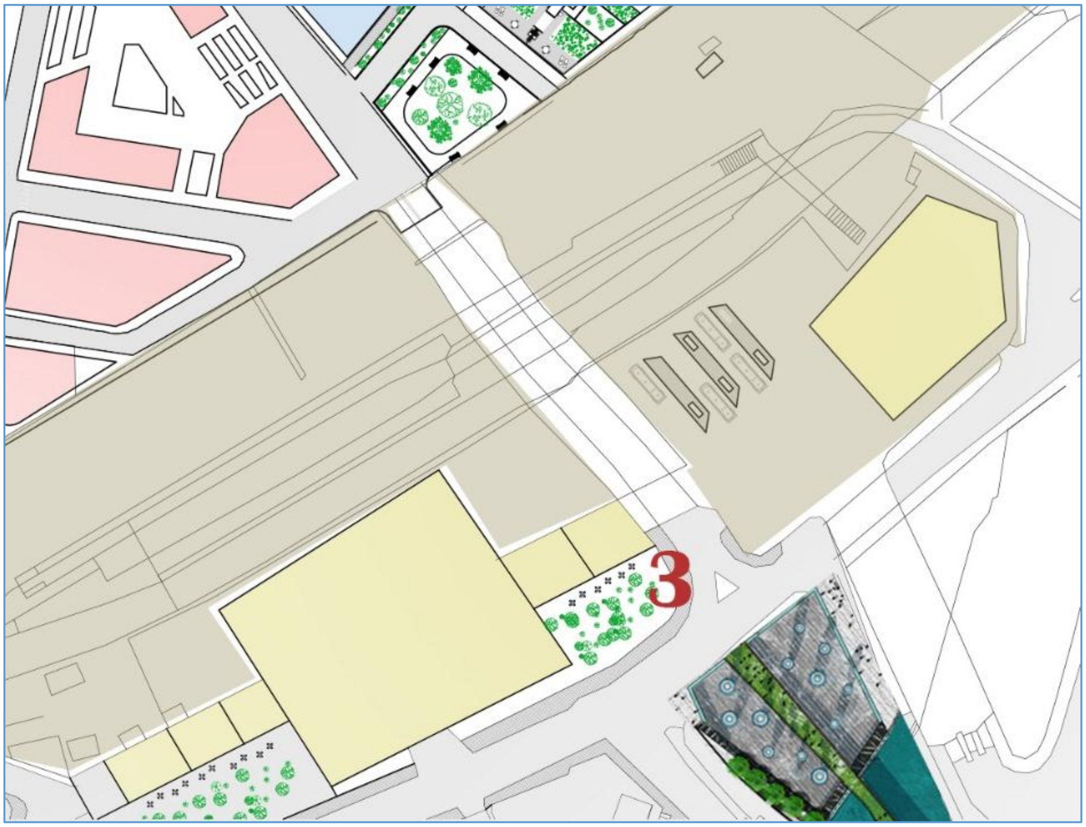
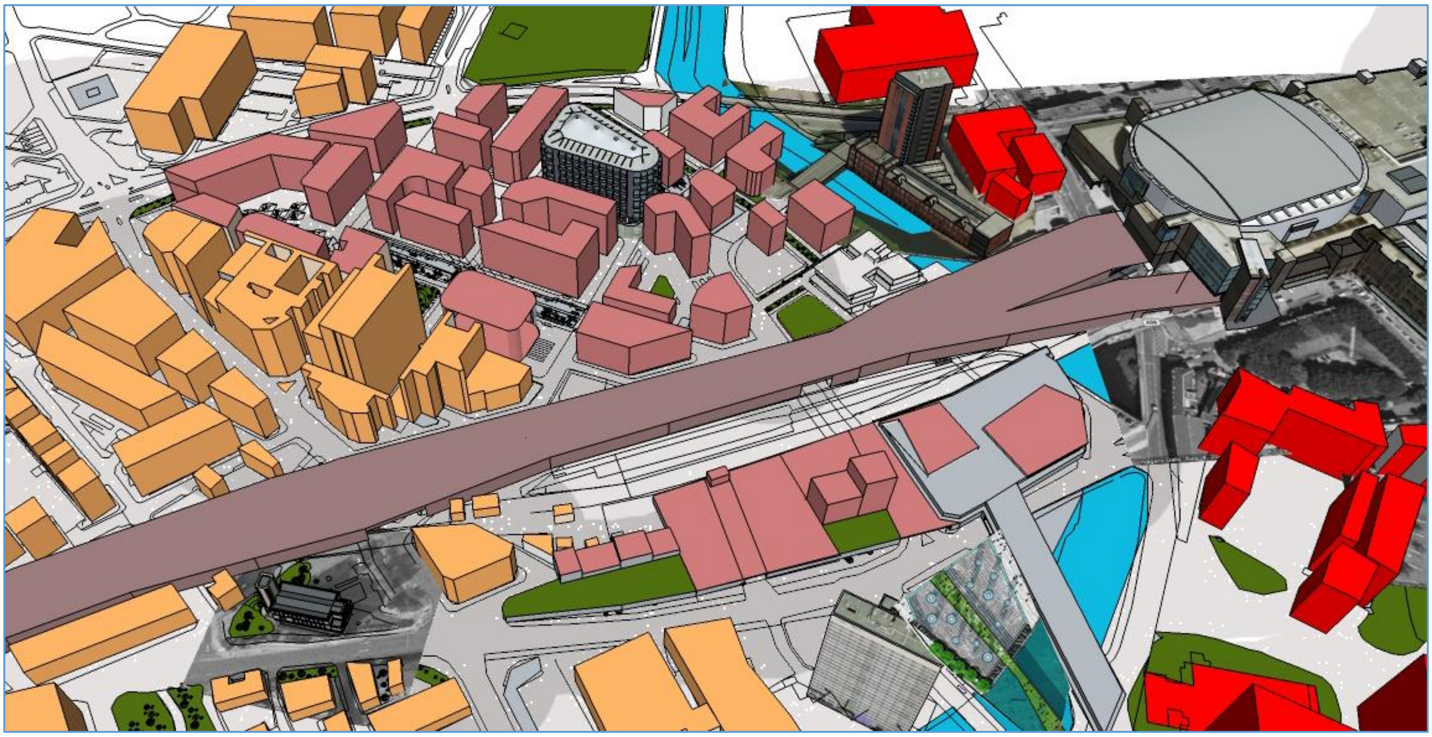
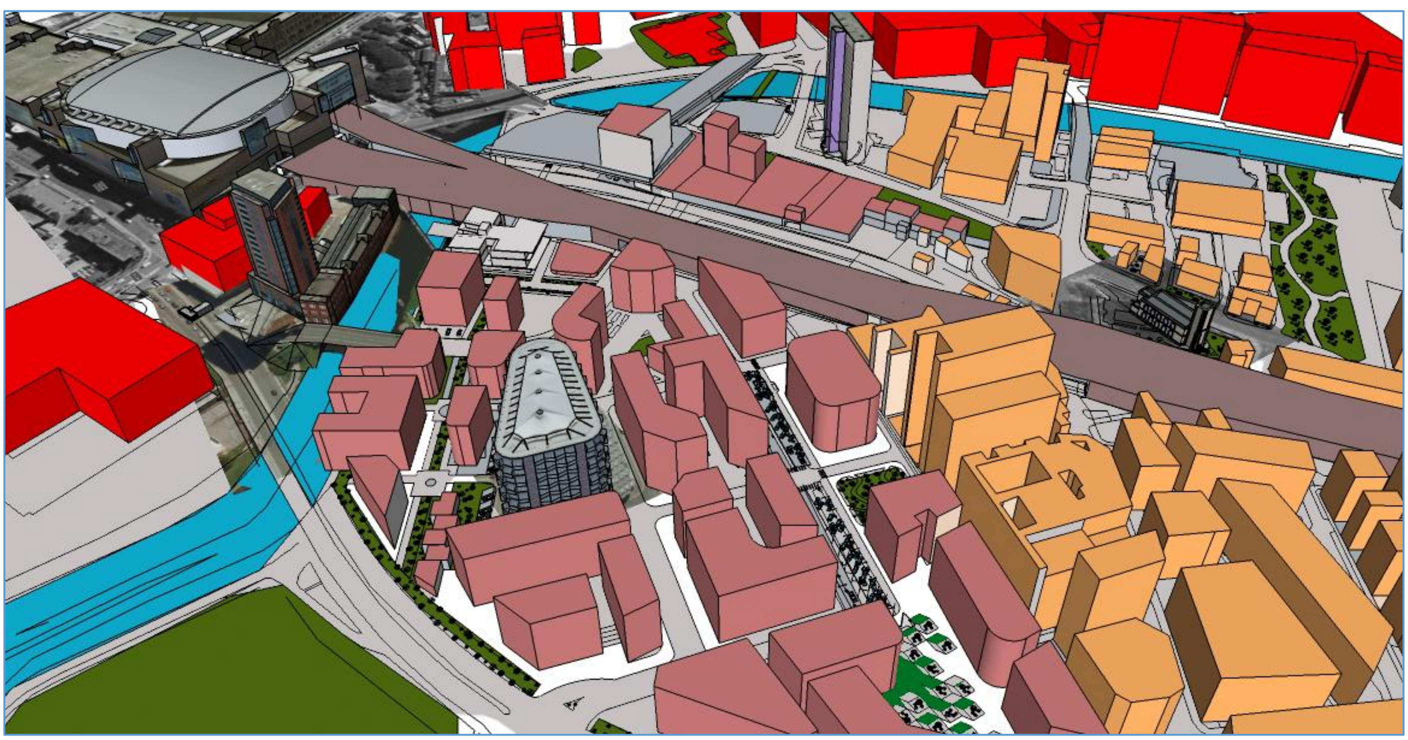


Figure 104 Zone 3

As a large part of train track is abandoned, as before they were kind of parking area for trains, we can apply two new functions on part of the track. As seen above, on left part we define a new transport hub , were a terminal for buses with leisure facilities and waiting area for passengers are designed. On right side of the tunnel we have a multi-floor parking which will help us compensate the many number of parkings, now dedicated to new developments.

2.7 Urban Design3D Model





ARCHITECTURAL DESIGN

CHAPTER 4

MASTER OF ARCHITECTURAL ENGINEERING – THESIS REPORT

3. Architectural Design

3.1 Introduction:

To have prominent architectural results, we need to have some idea of the context the building is going to be placed in. So we can have a look at old and new constructions and by studying their architectural language, we can arrive to an architectural dialogue that is would not be a stranger to its context and surrounding. In this chapter we revise the architectural tendencies in Greater Manchester area.

3.1.1 Manchester and Salford architecture

The architecture of Manchester demonstrates a rich variety of architectural styles. The city is a product of the Industrial Revolution and is known as the first modern, industrial city. 67

Public buildings: Manchester's first town hall, designed by Francis Goodwin, was constructed during 1822–25 in the neo-classical style with a screen of Ionic columns. Its facade was re-erected as a folly in Heaton Park at the west end of its lake in 1913. Manchester was granted a Charter of Incorporation in 1838. Classical architecture gave way to Neo-gothic and Palazzo styles in the Victorian Era. Edward Walters designed the iconic Free Trade Hall in the 1850s as a monument to the Peterloo Massacre and Manchester's pivotal role in the Anti-Corn Law League. Built as a public hall only the facade remains. The old town hall was replaced by the present Manchester Town Hall, designed by Alfred Waterhouse. Completed in 1877, its Great Hall contains the Manchester Murals by Ford Madox Brown. Manchester Exchange operated between 1884 and 1969 near Manchester Cathedral, most of the station was in Salford and its 1929 extension east of the Irwell was in Manchester and was linked with the adjacent Victoria Station.

Figure 98 Facade of Victoria Station

Early Victorian warehouses were built of brick with stone dressings typically up to six storeys tall with basements and steps to the front door. Fireproof construction was used towards the end of the century. They had loading bays with hydraulic wall cranes at the side or rear. Some traders built their own warehouses but others shared speculative

---

[67] *Manchester - the first industrial city*, Science Museum, retrieved 17 March 2012

developments that were built for multiple users. Warehouses were built into the 20th century, many in the highly decorated Edwardian Baroque style leaving the city with a

legacy of some of the finest buildings of this type in the world. The continuing urbanisation and narrow roads in Manchester have impacted on views of these ornate buildings, many of which were often decorative at the top of the building. A flurry of ornate warehouses were built, many of which dominated the area around Whitworth Street and included Asia House, Manchester, India house and Lancaster House designed by Harry S. Fairhurst.

Ship Canal House was completed in 1927 for the Manchester Ship Canal Company by Harry S Fairhurst in a transitional Edwardian Baroque/Art Deco style. Owen Williams designed the Daily Express Building with a futuristic dark glass façade. Nikolaus Pevsner described it as "all-glass front, absolutely flush, with rounded corners and translucent glass and black glass". Sunlight House which opened in 1932 on Quay Street was designed in the

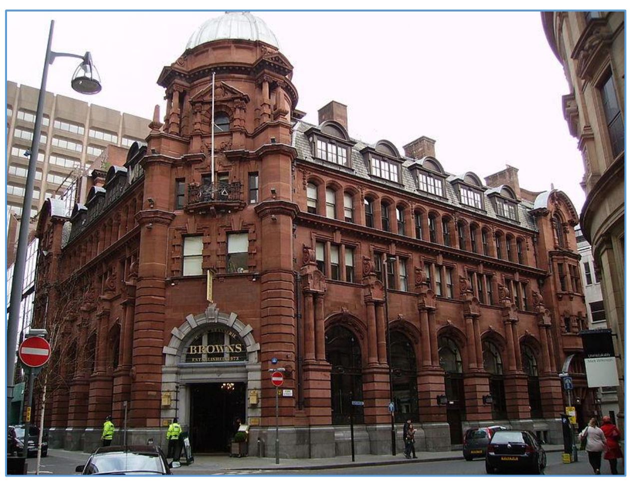


Figure 99 Clockwise: Lancaster House, Westminister Bank , Mosley street


Figure 100 Sun

art deco style by Joseph Sunlight. The brown-brick Redfern Building on the Co-operative Estate is an individualistic interpretation of the Art Deco, although Pevsner believed it shared more in common with 'Dutch Brick modernism'.

After World War II, work to rebuild war-damaged Manchester began and the transition from warehouse to office blocks accelerated as the city's industrial prowess waned. Few aesthetically memorable buildings were constructed in the 1950s and 1960s but some grew into landmarks for the city. The first major building constructed after the war was the Granada Studios complex designed by Ralph Tubbs in 1954. The studios' notable features were a lattice tower and red, neon sign.

Modernism: When the 118 metre tall CIS Tower was built in 1962, it was the tallest building in the United Kingdom. The tower by, Sir John Bumet, Gordon Tait and Partners with G.S. Hay, is recognised as one of the best 1960s modernist buildings. As home to the Co-operative Group, it was designed to showcase Manchester and the Co-operative movement. It was clad in photovoltaic cells in 2005 and is the tallest listed


Figure 102 Express Building

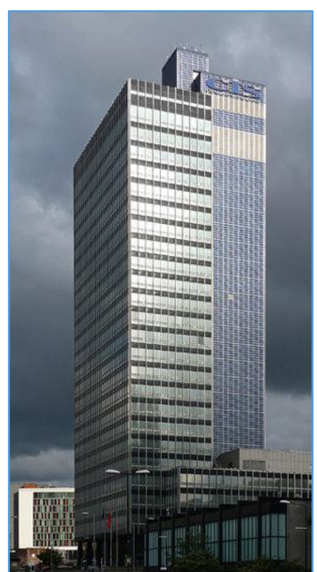


Figure 101 The CIS

building in the United Kingdom. Along with New Century House which also opened in 1962, its "design of discipline and consistency which forms part of a group with the Co-operative Insurance Society". Gateway House, modernist office block designed by Richard Seifert & Partners in 1969 on the approach to Manchester Piccadilly station, is considered to be one of Seifert's most loveable buildings.

New millennium architecture : After the destruction caused by the 1996 bombing, the city had a chance to reinvent itself. Tall buildings, many in a post-modernist style incorporating glass façades were constructed, the most prominent is a skyscraper built in 2006 – the 168 metre tall Beetham Tower by architect, Ian Simpson. Other buildings with glass incorporated into their design include Urbis, No. 1 Deansgate, and the Manchester Civil Justice Centre. Manchester City Council has been more sympathetic to tall buildings since 1990 and its Manchester Core Strategy 2012–2027 considered 'iconic' developments which reflect the non-conformity and uniqueness of the city would be viewed more sympathetically.

The Manchester Civil Justice Centre was built in 2007 in Spinningfields - Manchester's new business district. It has been well received by architecture critics who praised its aesthetics, environmental credentials and structural quality. The Guardian architecture critic Owen Hatherley described it as a "genuinely striking building"

Figure 103 Beetham Tower from below

Figure 105 Angel Square, front facade

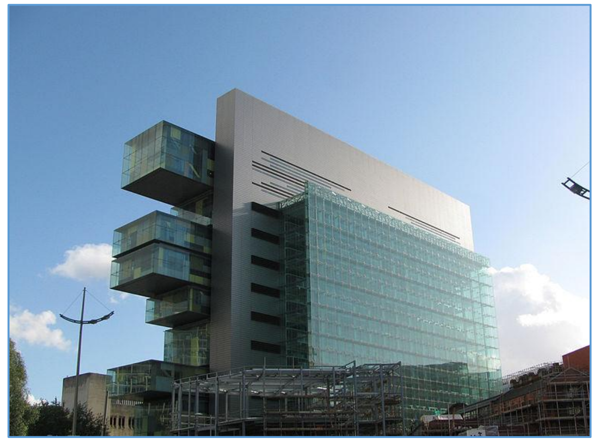


Figure 104 Manchester Civil Justice Centre

3.2 Refrences

3.2.1 Salford Greengate Example: .abito, intelligient living spaces.

Just adjascent to the site chosen for our building Salford, lays a building which is like new point of hope to furture, in the ignored greengate area.

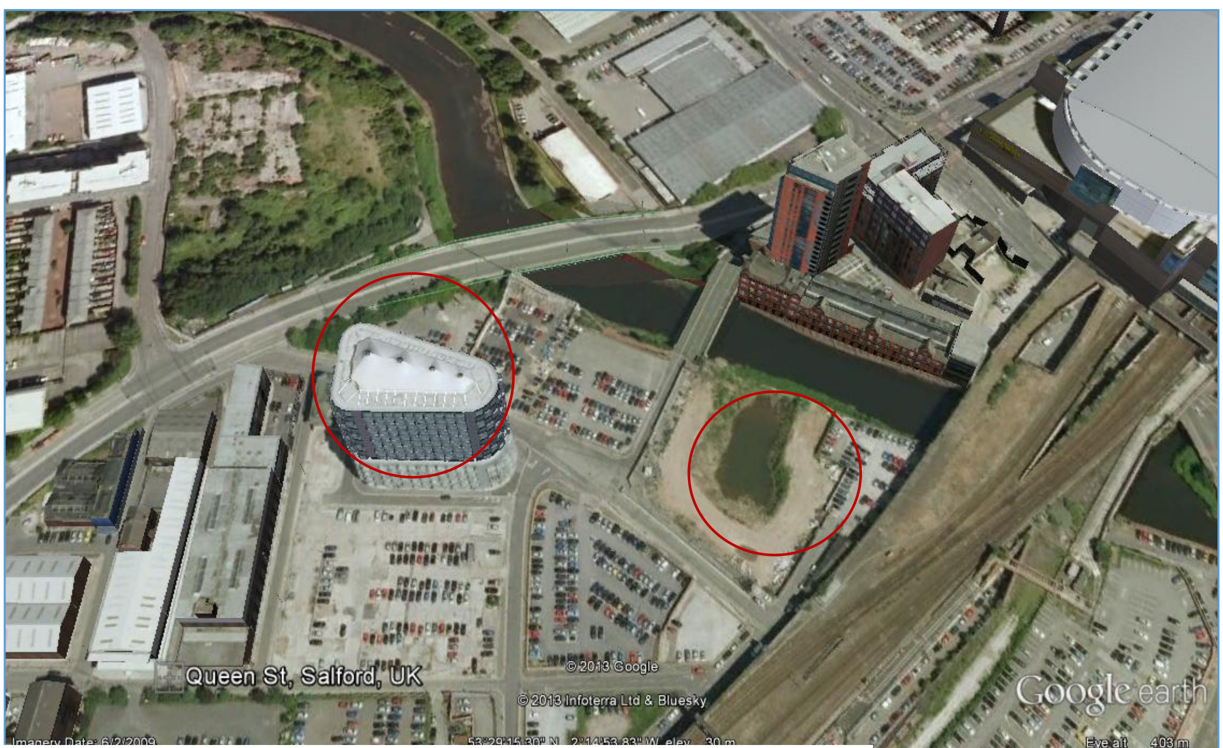


Figure 106 .abito project and our project site

.abito was a specific response to a recognition that many young professionals and first time buyers at the start of their careers were being excluded from City Centre housing markets by price .abito is the result of research and development to create an apartment which meets this key demand without any concessions on quality . The resultant abito concept was formulated through a rigorous process of R&D, over a 15 month period including the construction of a full size prototype. A generic design, layout, specification and pricing structure was evolved and has resulted in two locations coming on line in Manchester city centre (completed March 2007) and Salford Quays stimulating very considerable market demand. That demand reflects the availability of a quality product in striking well designed buildings at around a 20% discount to the cheapest one bed apartments in more contemporary developments.

Figure 107 .abito project

At the outset the brief for abito was to create a visually stunning development, using minimum valuable land space, housing a number of multi-functional apartments designed and built to last, while creating a design classic. The apartments were to appeal in design terms and price range to first-time buyers, young professionals and key workers who were aiming for city centre living.

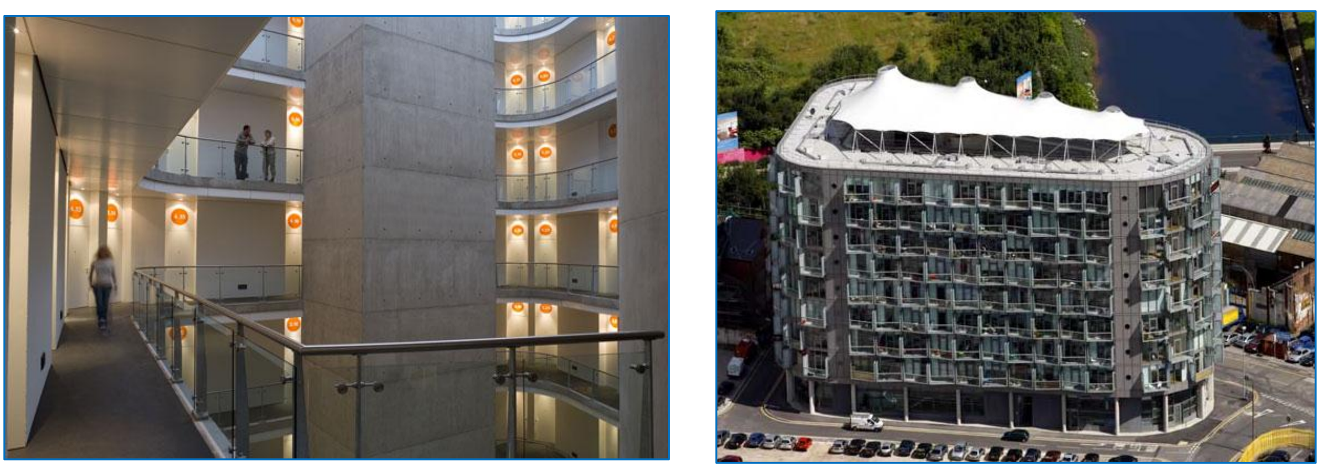


Figure 108 different view of abito project

3.2.2Example with similar location: Battersea Reach, providing one, two and three bedroom apartments and penthouses, is an award-winning development with a dramatic series of waterfront buildings that cascade towards the river's edge providing breathtaking views across the river to Chelsea Harbour. There will be bars, cafés, restaurants, shops, health and leisure facilities – everything to make Thames-side life even more distinctive and unique.

Figure 109 aerial view

Battersea Reach, SW18, is well located and provides good connections to London Waterloo train station. Fulham, Chelsea, Battersea and Wands worth are all on your doorstep, while the West End and City are within easy reach.

this kind of stair like structure that loses height as it gets closer to the river, seems one language to be suitable also for our project according to its similarity in location and conditions, though of course Times river is wider than Irwell river passing by our project site.

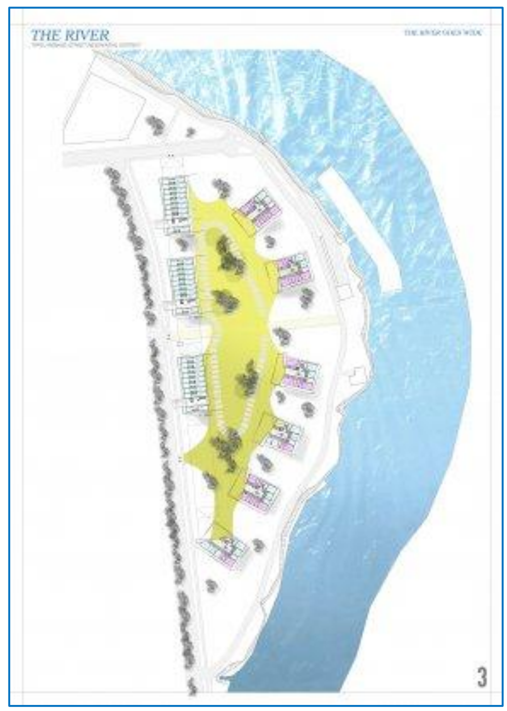


Figure 110 project plan

3.2.3 Architectural forms: We liked to have a kind of architecture made by linear configuration that gives the definition to horizontal and vertical lines seen on the façade of the building. Such lines could be done by slabs and cantilevers ejecting from the façade. Structure could then come into an architectural role as well. The example below can be interesting in this sense:

Luxury apartment accommodations have reached another pinnacle in the domain of modern architecture with an endeavor by Atelier Thomas Pucherand Bramberger Architects in the city of Tartu, Estonia.

This groundbreaking conception is a concoction of the economical aspects of low-cost

apartment living and the benefits of single residential homes.
These luxurious Villas or Penthouses are placed one on top of the other in a highly photogenic and strategic manner, to offer an immeasurable panorama, personal outdoor spaces and large living areas -all in utmost privacy. Moreover, the environmental benefits granted by reduced overall impacts on the environment due to the apartment housing backbone also ensure lower maintenance and building costs.
The project encompasses organized space that is apportioned in two distinct rings according to their functions, either 'living' or 'service' areas. The inner ring, or service ring, coordinates the service functions such as wardrobes, entrances, bathrooms and sauna rooms -also acting as a noise barriers to the lobby. The exterior ring, or living areas ring, yields private outdoor spaces with views and vast sunlight exposure. Moreover, its flexible floor plan allows residents to personalize their walls and interiors to their liking with ease.

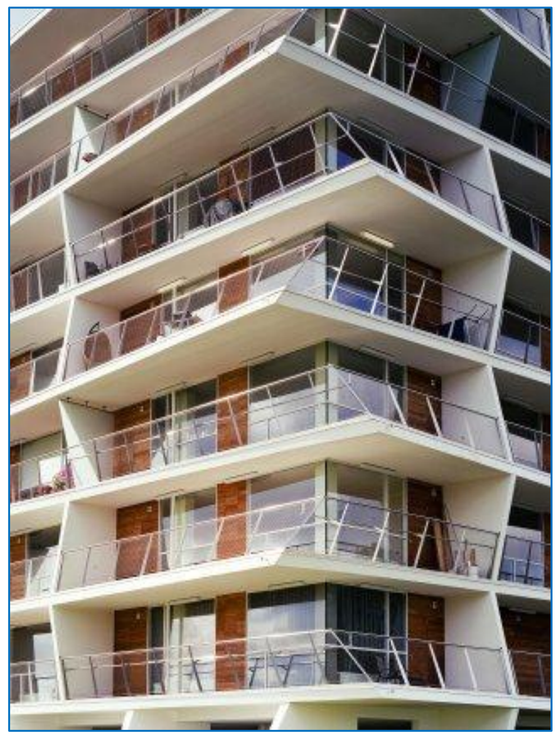


Figure 111 project facade

as seen from the last two examples that were architecturally interesting for us and they had location similar to the green gate project site, especially the Battersea project, we could have inspirations for our architectural design. We like to have a clean and functional architecture that also brings original ides with it and implies on what it was supposed to be.
in the next chapters we will examine the project site and its relation with its surrounding, and with inspirations by architectural works seen so far, we could start doing sketches on the building shape and type, according to the functions defined for.

3.3 Project identification:

Figure 112 red point showing the location within salford and manchester

As the request of the competition was development of 120 residential units, it was logical that the building we choose for further development be of the residential kind. As in our urban development strategy, a key plan was to bring back vitality to the area of greengate, we could expect a price rise of the ground in the area, and new building have the capacity to be of higher levels of quality. According to the site chosen after discussion with Professor Tadi, we found the field suitable for a residential complex of medium height.

Luxurious apartments: We decided to define the general concept of the architectural project as development of luxurious or high-end apartment dwellings. This is achieve through the use of modern technologies in units, high-end finishings, quality of built, and in their size and layout.

After studying of some interesting points in our urban master plan for further development of a building, we came up with a brown field located in the corner of green gate area, at a dead end near the train track, that does part of our green pedestrian path. According to strategies of Salford municipalities, they encourage a number of points to have in mind:

-leaving the ground floors to public function such as bars and shops and preferably not dedicating the ground floor to parking areas.

- paying attention to context architectural traditions, to name a few could be the redbrick facades, and chimney like structure.

-the heght limitations seen in the existing urban texture.

So we some guidelines and inspirations and general concepts, we start to examine the site better to know its capacities, its limitations and the urban and environmental relations surrounding it.

3.3.1 Project site: As mentioned above the site chosen for our specific building developments, is located in the corner of greengate area, and the left side of train track. The location is particular in some ways, as it is surrounded by four different types of urban elements. On its east side we have the train track, on its west side we have a car accessible dead-end street and on its south there is a private way beside a small size public green area.

on the north we have the Irwell river which has on its other side Victoria Train station of Manchester. The newly built .abito project is just meters away and the importan bridge of Trinity way is found just near it, which makes easy car access to the area. It is also just few meters from its south is near the tunnel of greengate.

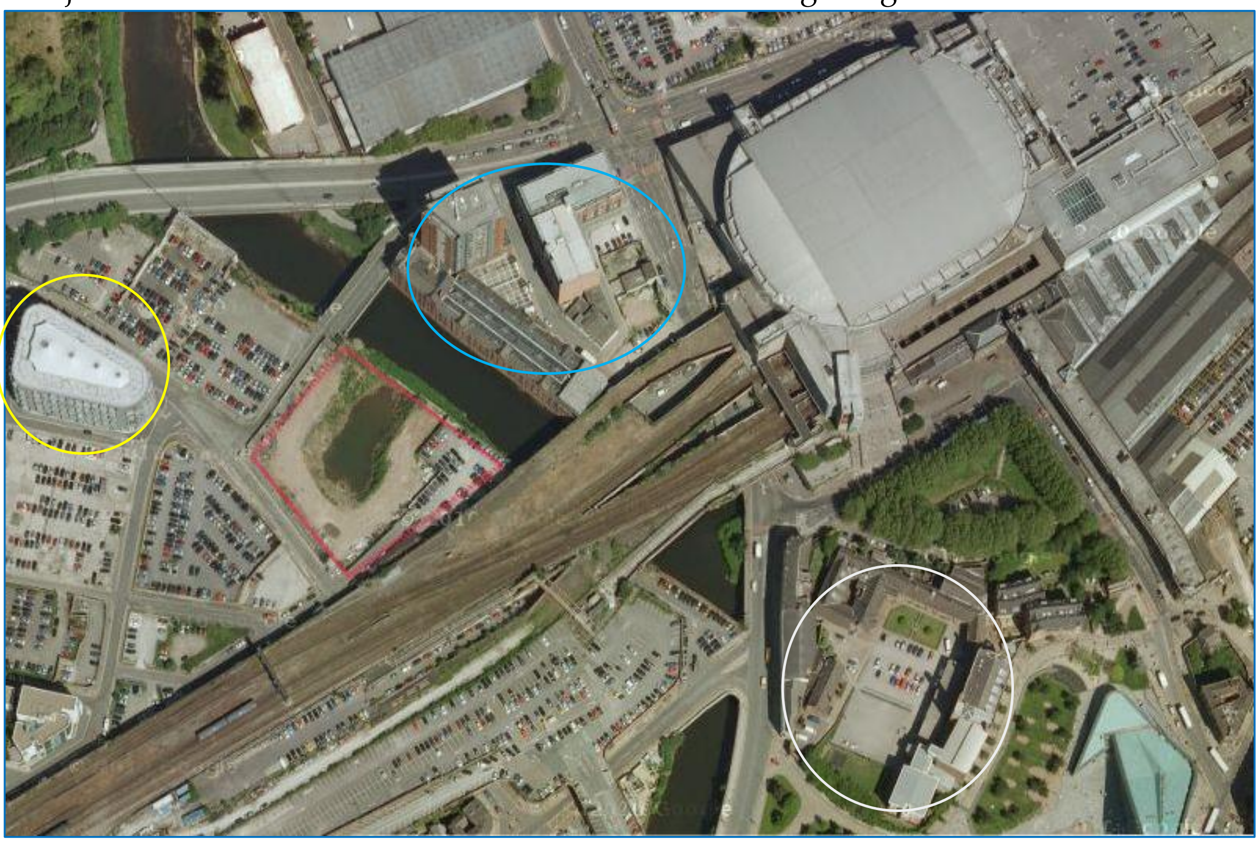


Figure 113 site project and near by places

In the figure above some the important nearby places and building s are marked. The legend of the figure is as the following:

Blue: Victoria station area Red : project site Yellow: .abito project white: manchester cathedral

The area marked by the red rectangle is not the precise project site as we have done modification to what is seen in the map taken from Google maps. To have the precise evaluation of the area dedicated to the project of our construction, should be studied from the master plans. The field is about 38 meters long and about 28 meters wide which on two sides has car access and on two sides has just pedestrian access.

Figure 114 Master Plan showing project site

This makes and area of about 1100 m2 and a perimeter of 136 m . The site has an orientation towards south-west north-east direction. The site find a number of important pedestrian and car paths in its vicinity, as they are displayed in the figure below.

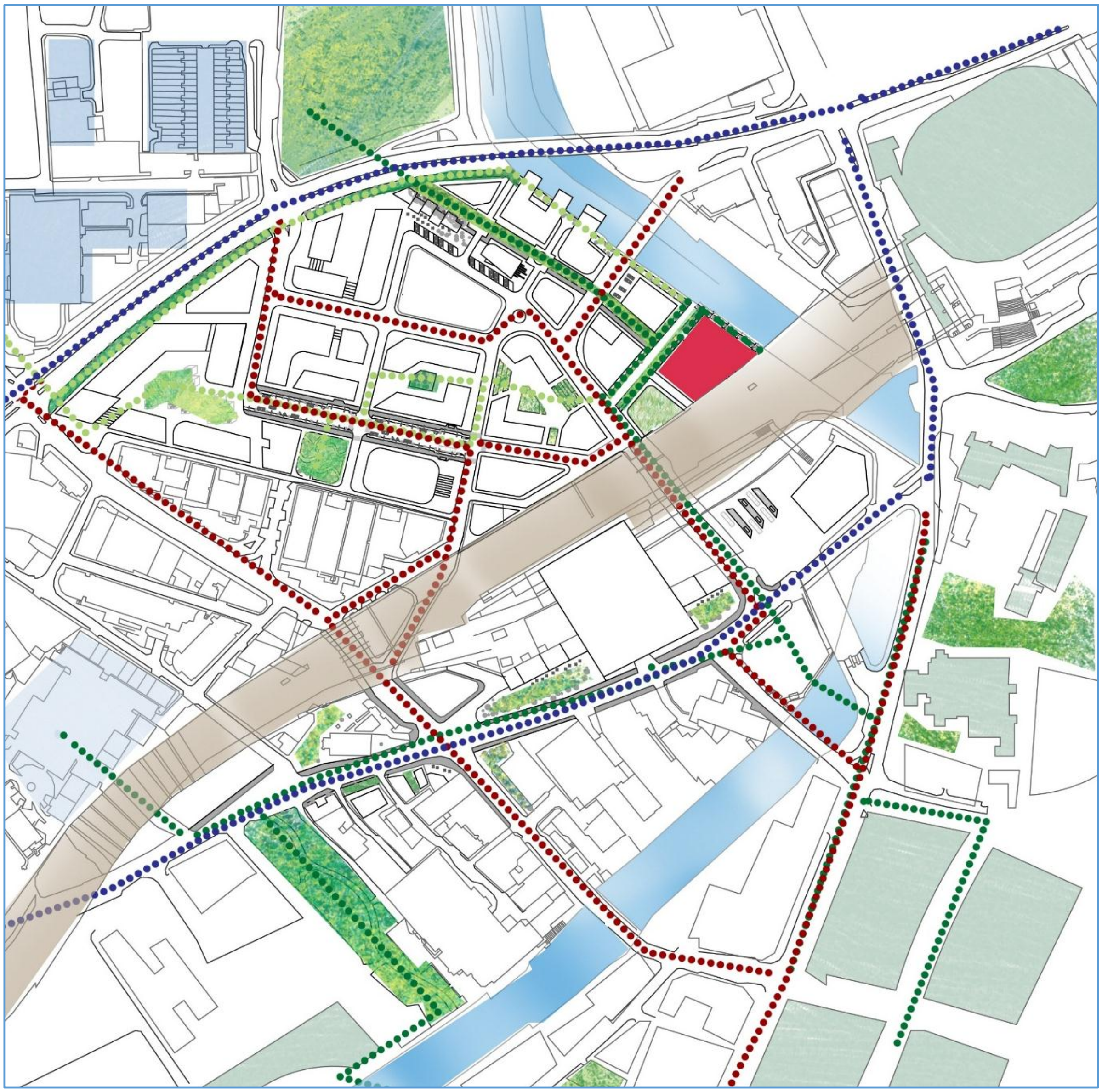


Figure 115 site situation in master plan

Green line: Pedestarian green path Red line: Main roads between Manchester and Greengate area

Blue line: Main inter-city connection

The highlights show important public places in light green and the light blue color show the main residential areas, and with the paths displayed, we can see their relation with different paths in zone.

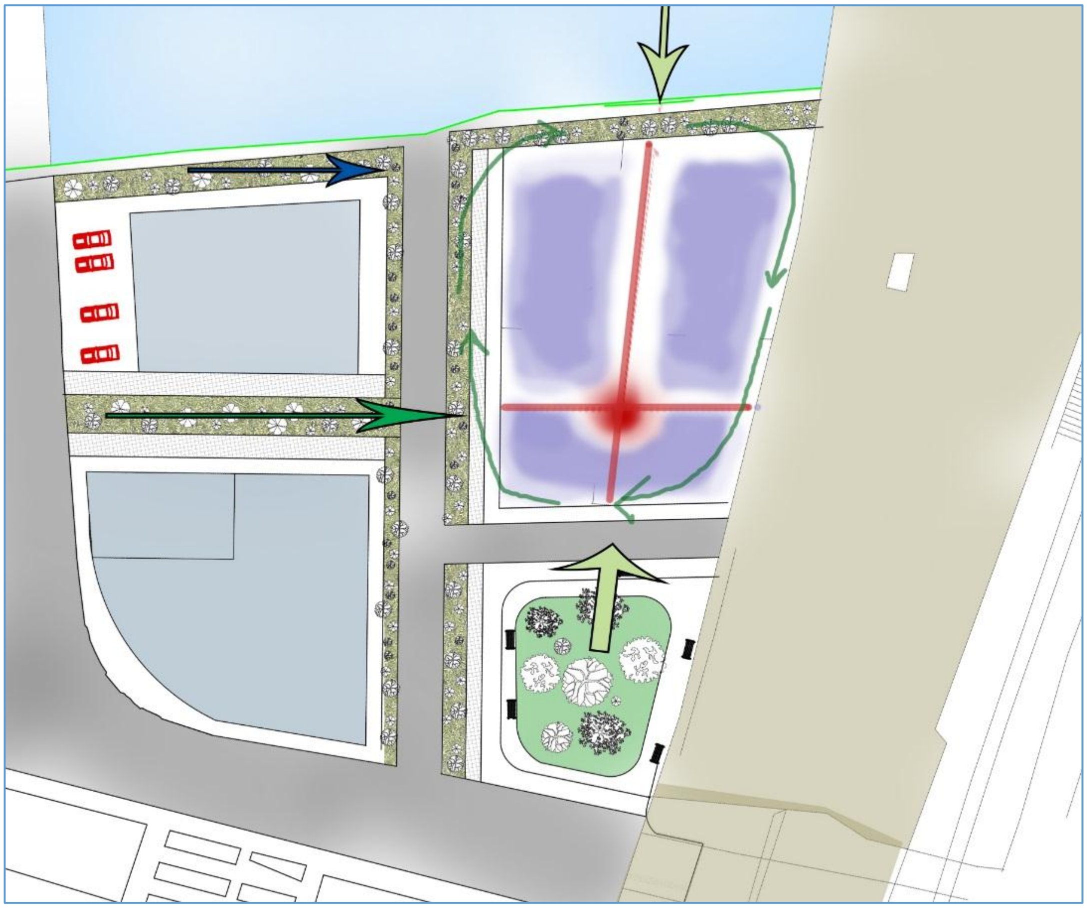


Figure 116 effective axis on site

Our site takes influences of its surroundings, especially by the arrows specified above. These arrows make two important axis of influence as specified by read color above. As the site is located in the corner of green pedestrian belt, the flow and movement on ground level can still continue around the site. On its south the view to the park and sun orientations makes a good possibility for large fenestrations.
from left we see and important pedestrian path arriving to our site, and from north we have the river with some nice buildings on its other side, which makes opportunities for nice view, and makes the use of large balconies on this side interesting. On south we have a small private path that serves only as for car access to the parking lifts.
These guidelines can give us frameworks for sketches for a building on the site. As mentioned before the area is designated for low rise buildings of 3,4 floors. We started on sketched on the volume, having in mind the references seen before and our ideal goals.
then from a better defined volume, we try to design the units itself and define their dimensions and style. The early plans then were revised by professors and the

modifications asked by them, led us to the final layout of the plans and shape of the building.

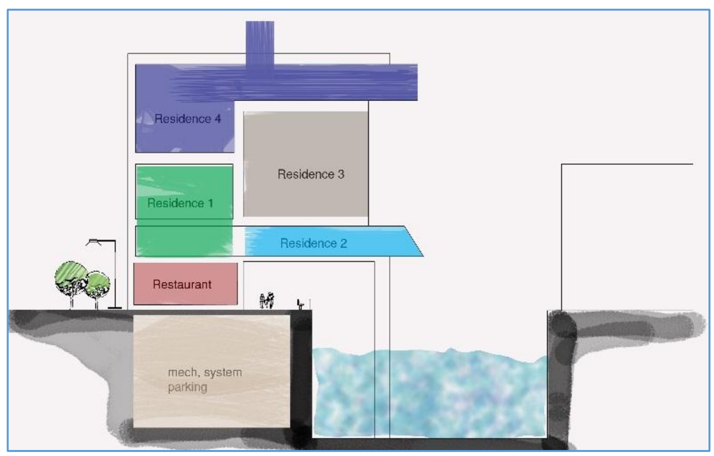
3.4 sketches and concept definition:

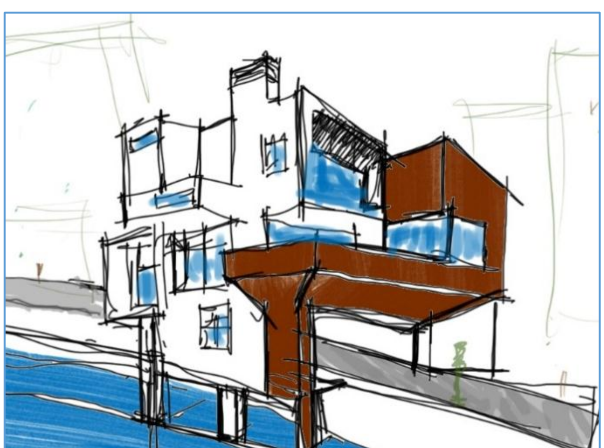
The concept of the building function was to have a 3,4 storey building, with high efficiency energy performance, which contain 4,5 residential units which could be identified as luxury apartments for prosperous greengate in future. We considered occupying to a max 75 percent of the field, and leaving the majority of ground floor area open to public purposes.

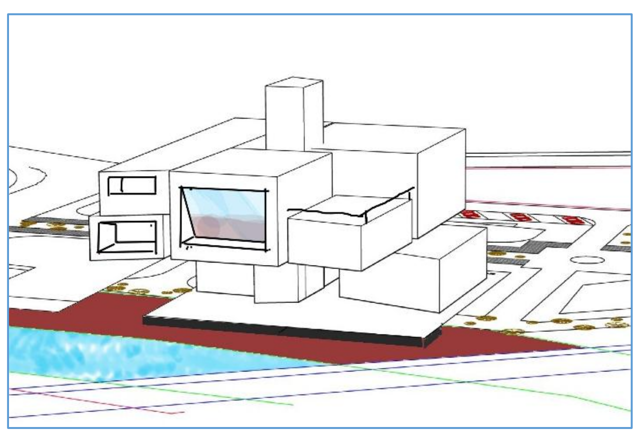
3.4.1 volume sketches: the very initiative idea of how treating with a building very adjacent to river, was even one to have legs in the water of Irewell river. The mere idea of a volume advancing the river border and coming over it and into it, seemed interesting. Like the ones of Silodam project. The Housing Silo is situated on the IJ River, at the tip of the pier, next to two former grain warehouses (silos) that have been converted. The IJ River served as Amsterdam's harbor in the golden age.

Figure 117 Silodam ,Amsterdam

so we began to do some sketches on a volume that is located near the river, but in very early stage it was obvious that because of the narrow width of Irwill river and immediately having the other edge of the river a row of building, such and iidea did nolt seem to work well at all. Looking and the sketch examples below gave us the impression that according the costs







and complications of such a work, the results may even be bad and not even pleasing for the abitants of the residential block and for the general face of greegate area.

The Irwell river at its average has a width of 15 m2 and that is why even stay back a bit from the river bridge is better. So we started working sketches with inspirations but examples and reference cases we had seen before.

we started working on the volume with the axis seen in the site analysis, and where they interact each other, would make us a vertical ax, as the latter two are horizontal ones.

we simultaneously had in mind the possible layouts of flats so the volume would not go somewhere far from its designated functions.

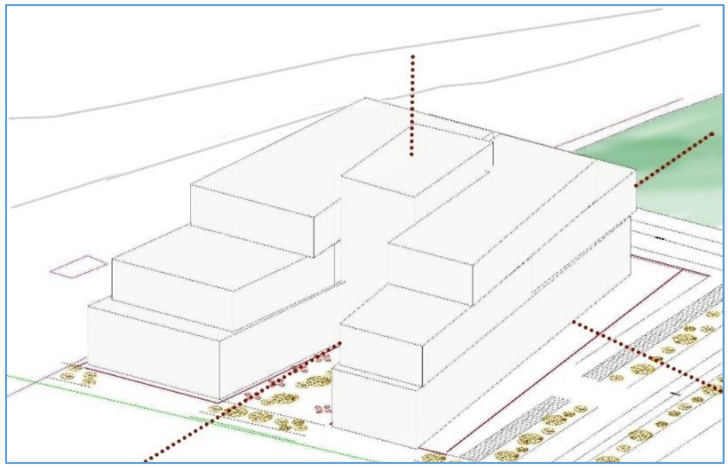


Figure 118 early configuration

We wanted to have the horizontal and vertical lines impression on the facades and genereal volume of the building, and leaning it towards the river in a stair like configuration is also desirable as it gives the possibility of large balconies and gives a shape to the building which could be pleasant to the eyes.

So we tried to cut more details out of the volume to see the effect of above mentioned ideas. We thought to have strong and long horizontal lines on façade that extend along the lenghth of the site. We tried to have cuts on the volume where the before mentioned axes influenced by urban layout of the site surroundings, pass from the site.

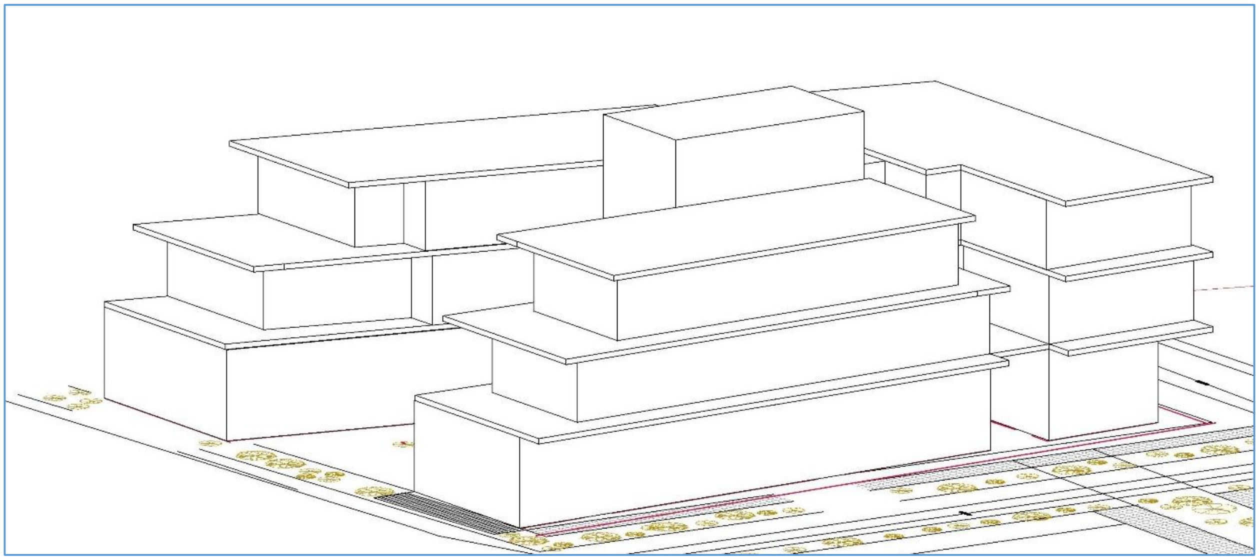
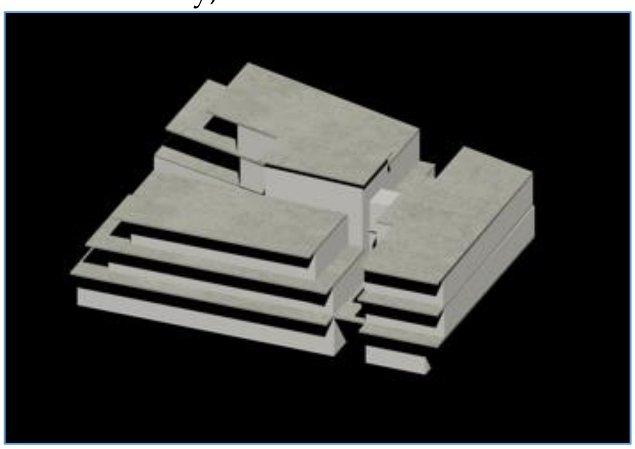
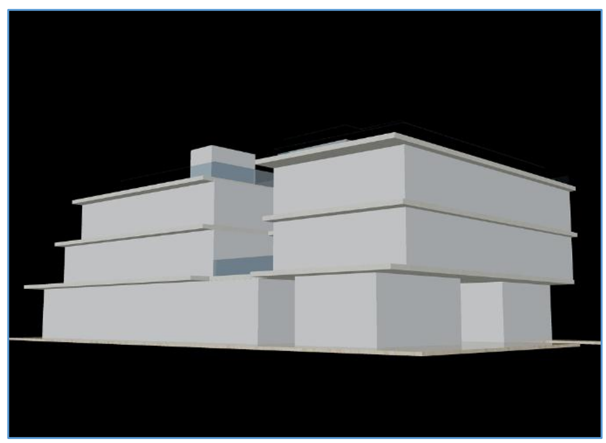
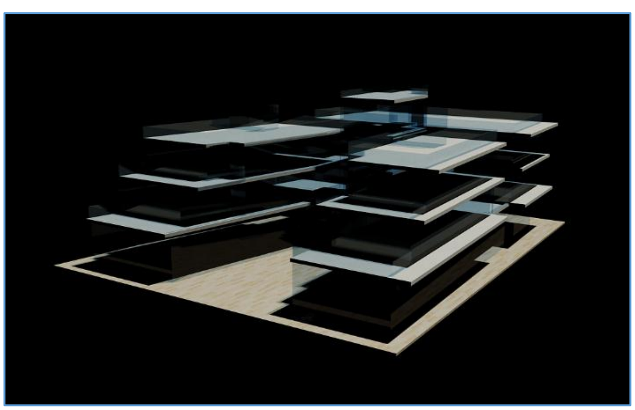


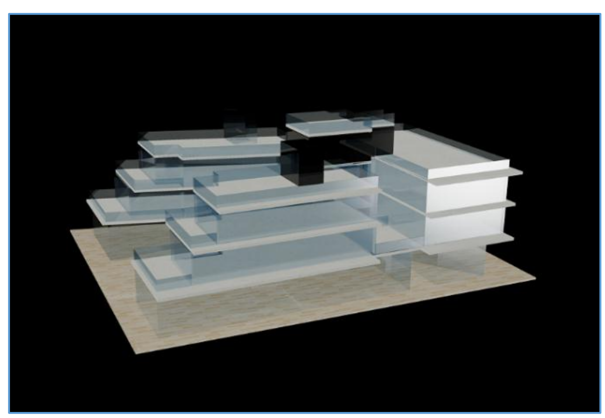
Figure 119 volume studies

The next step was to study the level of transparency or dullness of the volume. To define it as heavy, concrete block in the angle , or a light transparent structure trapped near the heavy, cruel train track?









The two volumes above show the extreme case of opaqueness and very visually heavy structure. Such a soled architecture can be nice if strong cake like pieces are cut out of it, and the fenestration maybe as low as possible. On the other hand the two pictures below show and extreme case of transparency, with the idea of except the concrete slabs, have all the envelope of high transparent glass. In the end the pleasant option for us was to stay away from the extreme conditions, and have a semi-transparent façade, made of large transparent windows and minimum amount of wall panels.
so till here we defined in our concept to have a leaning structure towards the river that is achieved by a stair like structure, to have strong horizontal lines on the façade and around the volume and to have a semitransparent envelope. This elevation presented below shows all these ideas at their early stage.
We stop studying the volume at this level and start working more on plans. In a way we could have better idea of the necessary dimension that effect the volume, and the layout of the spaces which determines also the design of windows and openings and shape our envelope.

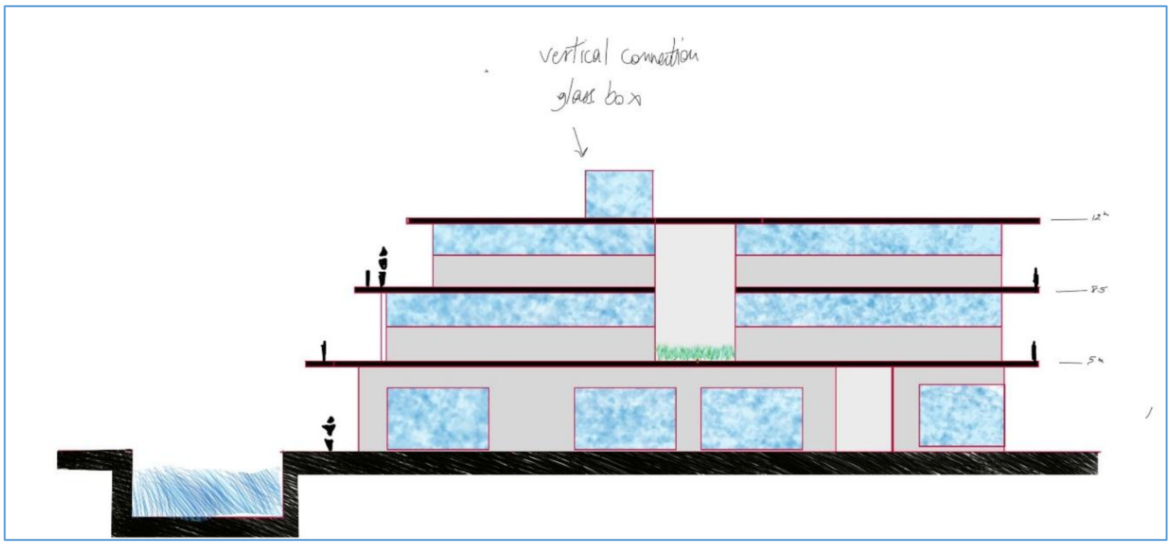
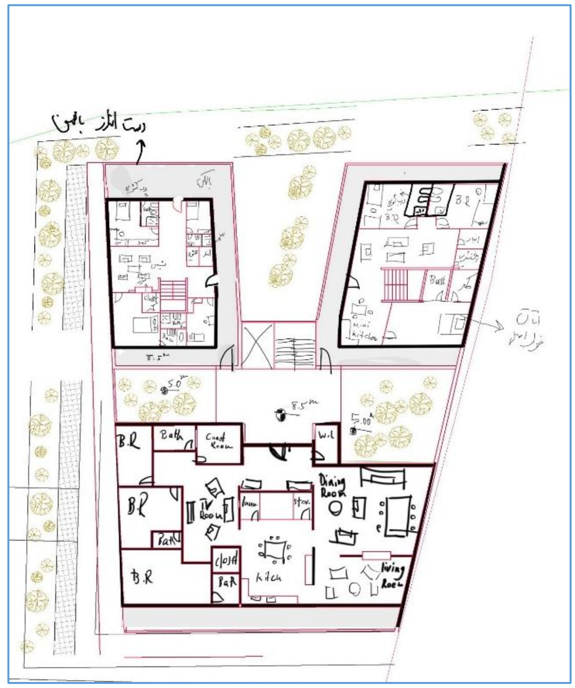


Figure 120 Section Studies

3.4.2 Plan and Laayout Sketches: we considered having the ground floor mainly dedicated to spaces open to public, such as bars and restaurants. The strains on the site given to us by the axis effective on our site which we saw before, gives us the idea of having 3 semi separate blocks on the site. If we dedicate each block to 1 or 2 units , we will have the desired number of units.



The early zoning on groundf floor was layout that is almost attached to the train track and thus blind from that side, but containing some shops, bar, restaurant and the lobby to the residential units. On such a general layout we based the higher floors, and found the dimensions suitable for 2 duplex units and 2 single floor units, making four apartments in the building. The figures below show the early layout studies.

so the further developed ideas was to try placing the main spaces on the sides receiving more sun during the day, to increase thermal efficiency. Also the extension of floors can create balconies. We have placed the vertical connection between floors in the point where the urban axis met, and we have seen a general configuration that can work, to include four units in the building, the next step is to further configure the layout, to start developing façade concept and to further form the volume of the building. A green roof is a great choice for this project as we will have large areas of roof and with the few number of occupants , they can enjoy their roof best.

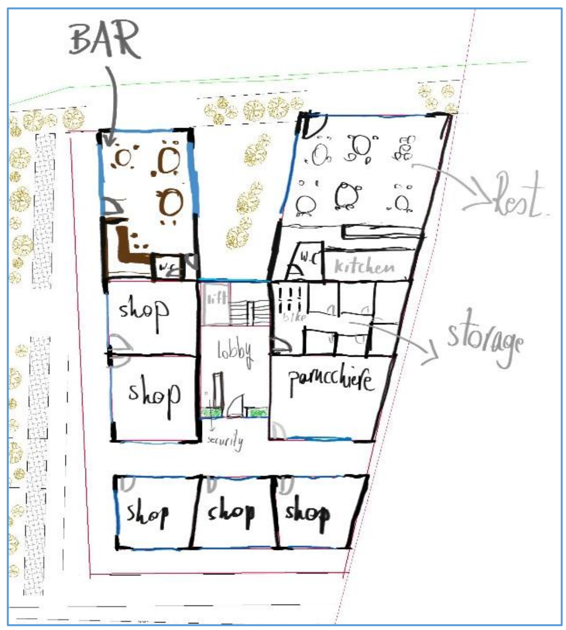


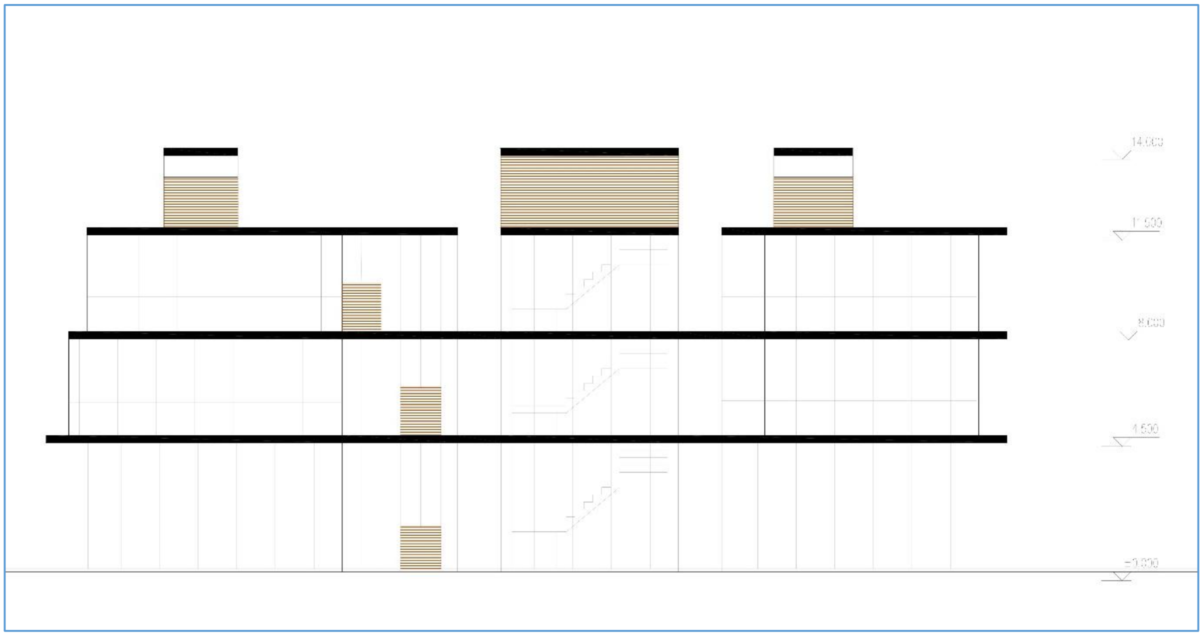
Figure 121 plan studies

3.4.3 Façade Sketches: As discussed above we decided to have a semi transparent façade to be made of large fenestrations and wall panels. Then we will have the horizontal lines. In these early sketches we try to see a bit of colors also, to match the colors of the architecture of area. The figure below is a better developed idea of a sketch. The wall panels could be of different materials in such a color range which creates a nice contrast with the very light blue of the windows glasses.

Figure 122 appearance study

So as seen here we tried to have the spaces located on ground floor more transparent also because the are open to public and this we can have a sense of invitation. More than that, in this way we will increase the safety of the zone as people stay in the public spaces and crimes are hard to happen in front of everybody! In this concept the wall

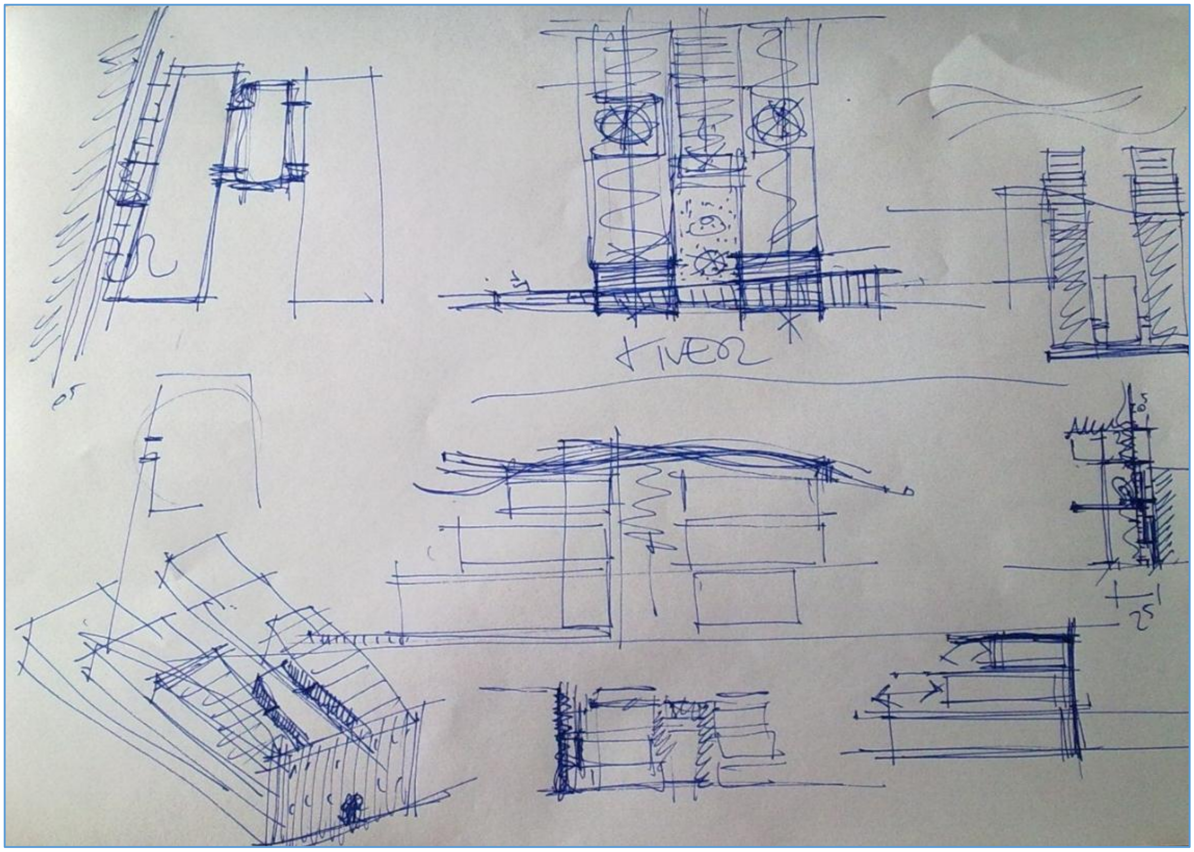
panels are mainly placed where we have the coloumns, and against the bathrooms to provide more privacy.
Here we see another option for the façade that has more attention on transparency which results in more visible horizontal line extensions. The lenghth of wall panels are limited as much as necessary to place like toilets which require privacy.



At the end of these studies and possibilities , and with the latest revisions we had , we tried to go into defining well the details of the building.

3.4.4 Revision and Final considerations:

After studying and doing sketches on different aspects of project, the revision with prof.Tadi gave us the final guidelines before further development of the project. The image below represents some of his considerations:



The main points to be applied into the dsesign were:

-leavinbg a minimum of distance between the building and train track, allowing the pedestarian flow all around the building.

-having more emphasize on the stair like leaning towards the river.

-having a strait and rigid façade on the side facing the green space .

-emphasizing the separation of blocks, on vertical and horizontal senses.

Bim Adoption: Finally the drawings where developed in Autocad, in a more accurate way to check the structural possibilities and issues. After better definition of building components and plans, we started adopting the building design into revit, so we could do further developments on a Bim based design system. The BIM model later gave us lots of advantages to do different analysis on Technological solutions of the building. Also the presentation abilities of the BIM model in Revit has been very impressive. We obtained lots of renderings and drawings and the model was representing quickly every modification applied in the design of project.

3.5 Final Layouts
3.5.1 Ground Floor and public spaces:

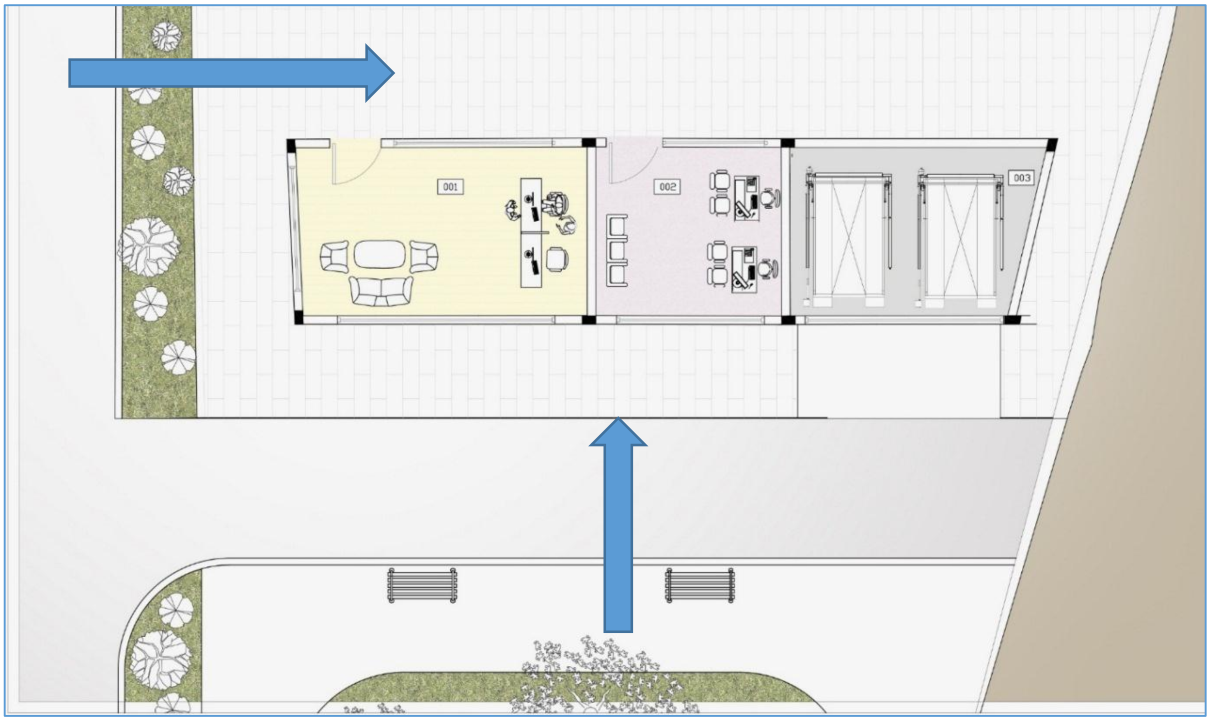


Figure 123 Ground Floor South side

The spaces located on the southern side of the ground floor are"
001- Travel Agency 002-Real Estate Agency 003- Car lifts for parking
These two agencies enjoy the view of the green space located on their south. They have entrance on north where there is the corridor in which open also the doors of the barber shop and the lobby of residences. This corridor is in the extension of a main green pedestrian path.

In the figure on right we see the entrance to the residential units. It is contains the stair case and two lifts, in the lift wells and along the vertical access the mechanical equipment ducts are placed. The structure of this element which is a vertical connection between different floors, functions separately from other blocks and has bridge like connections. The area of this vertical element is about 42 square meters .

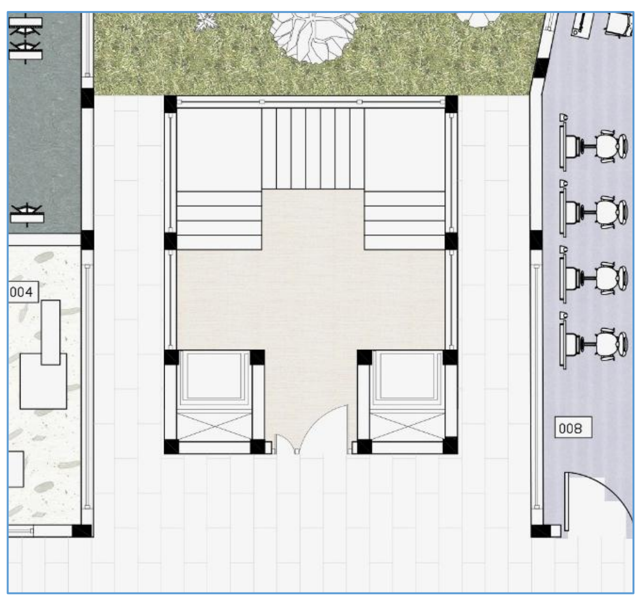


Figure 124 lobby area

The left wing of the building on ground floor contains these spaces:

-004 Shop

-005 Art Gallery

-006 Bar Restaurant

These spaces are located in the extends of pedestrian green path and can play an important role in livability of the neighborhood which results in a safer area.

the Bar Restaurant clients can enjoy the view of green areas around and in good conditions of weather, there is the possibility of using the deck outside that extends close to the river. It has an area of about 110 square meters and with its 36 seats can serve the clients.

The ground floor is intentionally higher than other floors floors which makes a better sound and view protection for residences above and makes a covered passage way along the wing.

On the other side of the building in ground floor area, we have:

-007 restaurant

-008 Beauty salon.

Both spaces could be attractive to people living in the neighborhood or to those who come to the newly developed Greengate area for leisure and needs.

The restaurant enjoys the Irwell River on its north and the granary of the interior garden of the building. It has opening towards the train track walls on its right that with a good lighting design can use those old brick walls as scene tic part of design for the passage turning around the building.

The high-end restaurant is 130 m2 big. The beauty salon has an area of 122 m2 big and car serve 15 clients at a time.

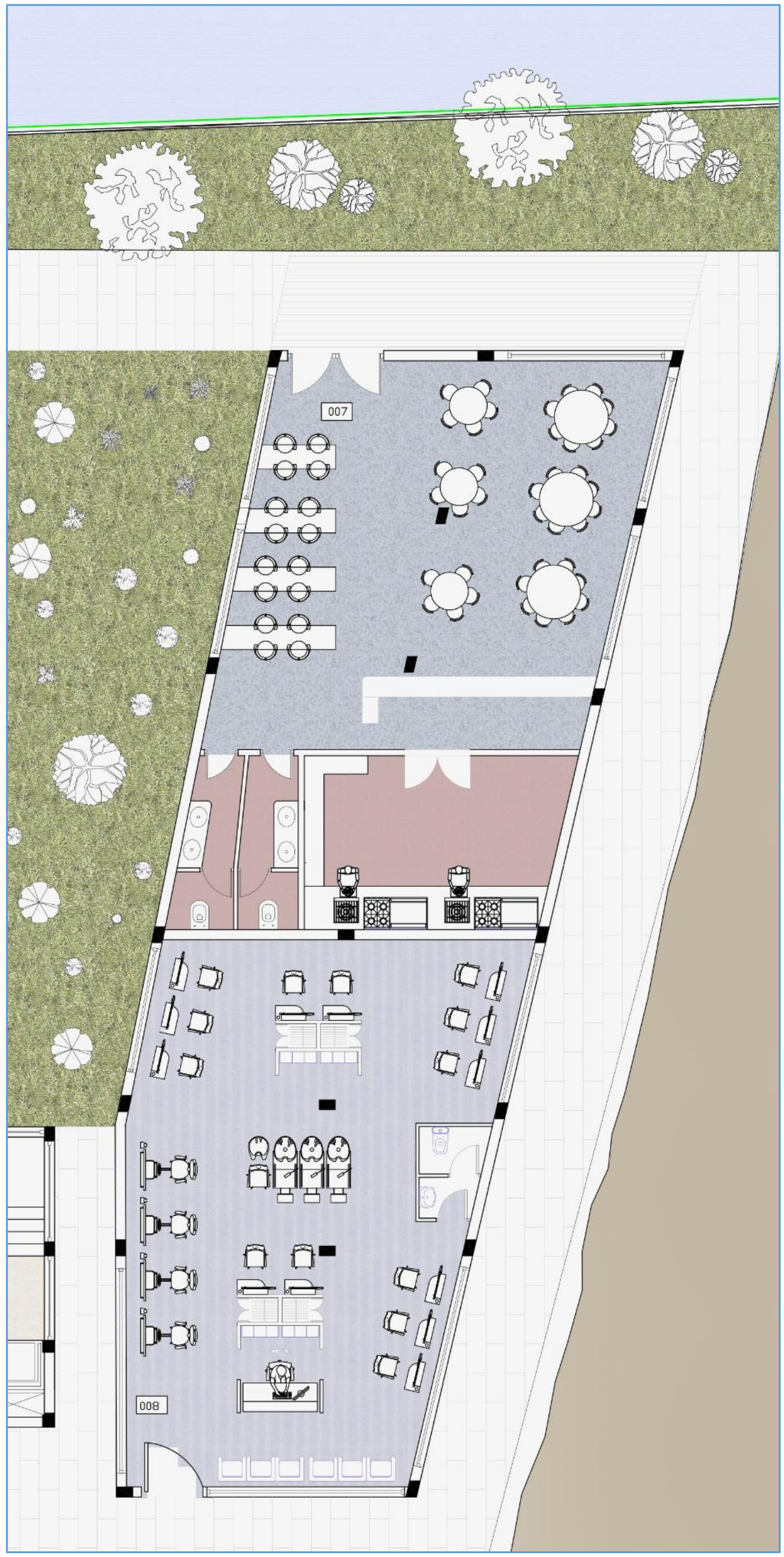


Figure 126 Lobby View

Figure 125   Ground Floor Shops

3.5.2 First Floor Plan:

3.5.4 Second Floor Plan:

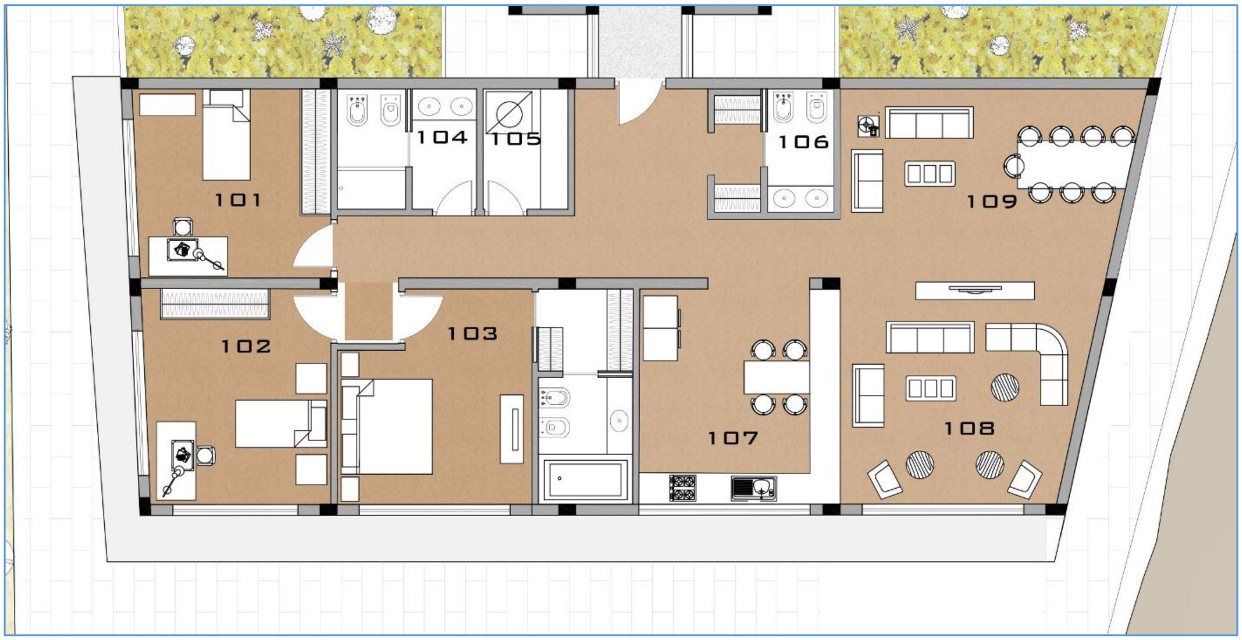
3.5.5 Roof Plan

3.5.6 Under Ground Floor :

The car lifts bring the cars from ground floor to this level, where each unit has two parking spaces. We have the entrance to stair and lift access, a sport facility and gym , a storage room for each unit and a large mechanical equipment space.

3.6 units description :

3.6.1 unit 1 and 4



101	Bedroom	102	Bedroom	103	Master B.R	104	Bathroom
105	Laundry	106	Toilet	107	Kitchen	108	Living Room
109	Dining, TV room			Area: 210 m^2			

These two units that have the same layout and are repeated in first and second floor, have two facades with large fenestration that enjoy sunlight and two more opaque facades as they face the train track and the two other residences of the building, to insure their privacy.

Therefore all the important spaces are located on these two sun receiving facades. The kitchen and living room and bedrooms are the spaces placed on these area

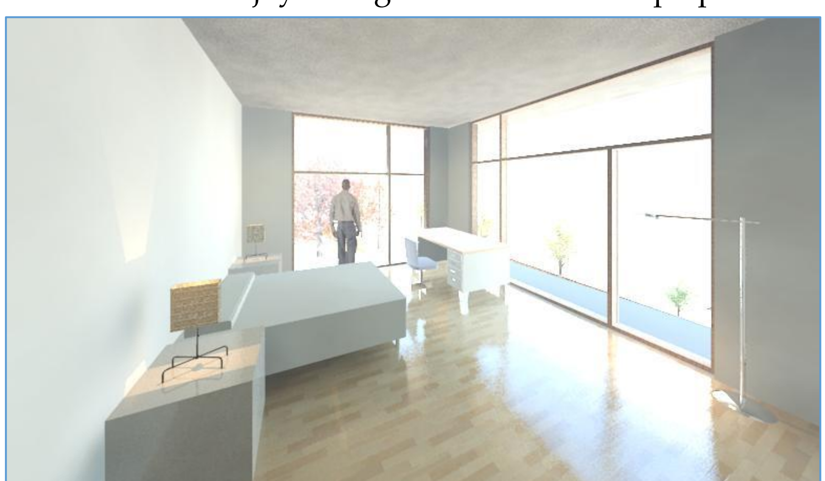


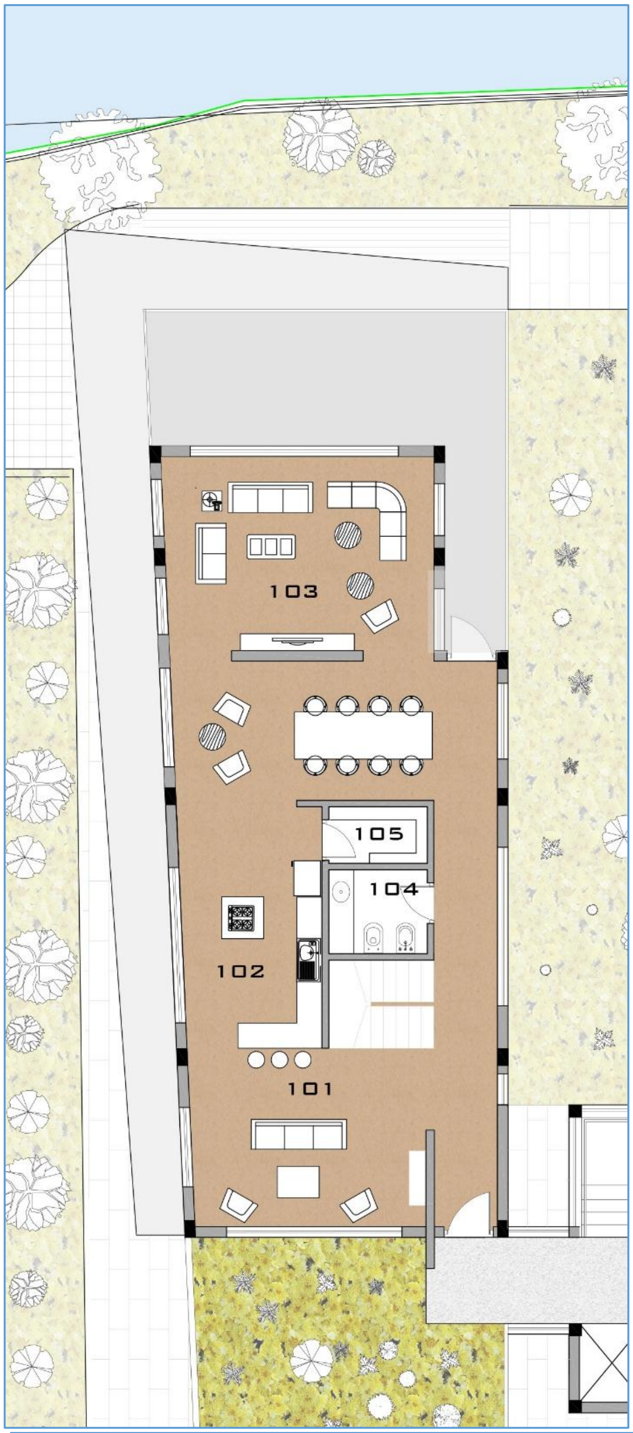
Figure 127 view of 102 Bedroom

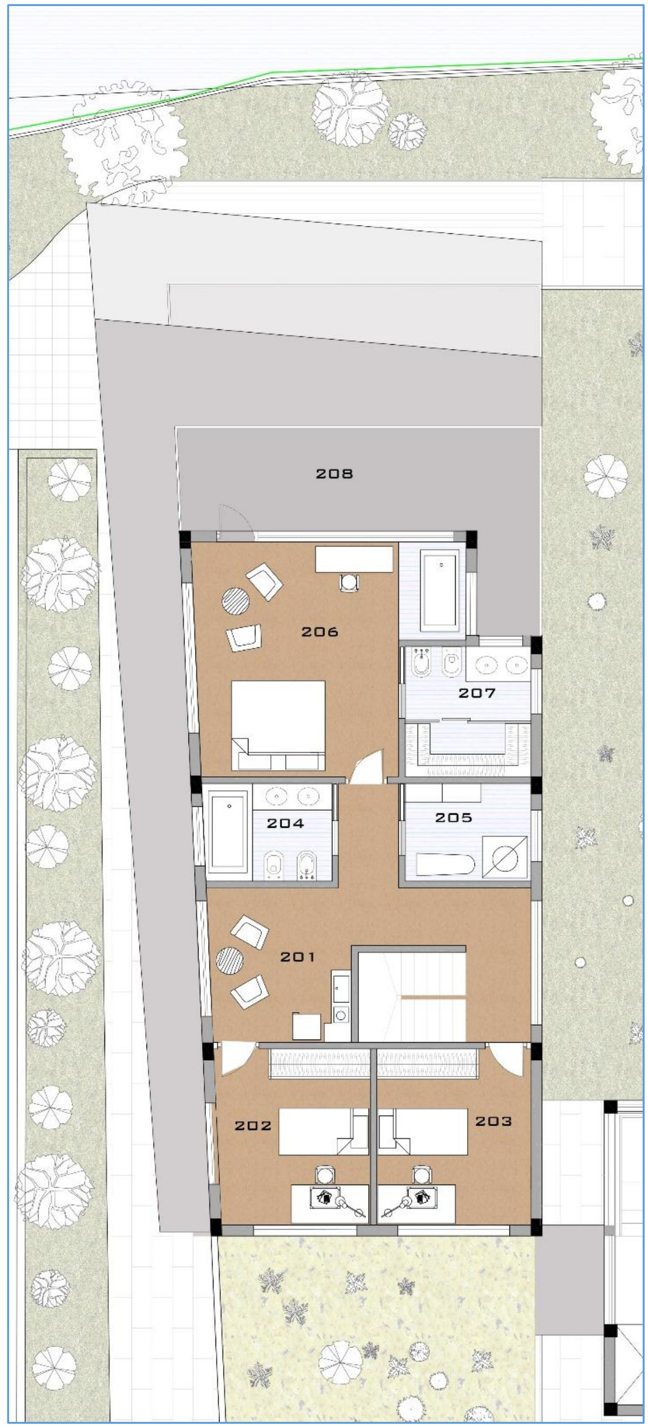
which get the sun of south east to south west. As seen in the plan above the shading is applied for these windows. On the upper side of the plan where there is less light, the service zone and the TV room are located.

In this regular plan we have perfectly fitted the function of spaces in compliance with environmental conditions. These units enjoy views of the green area located in its south.

Figure 128 view of the two units

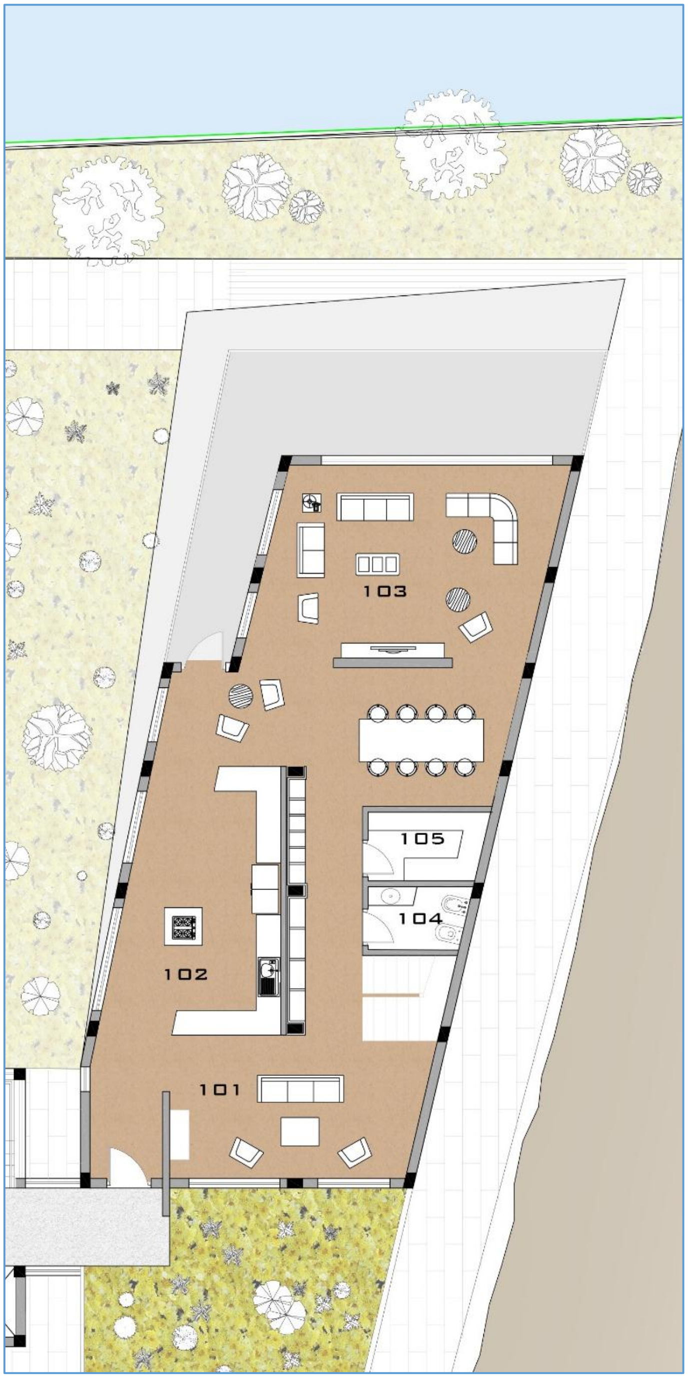
3.6.2 Unit 3

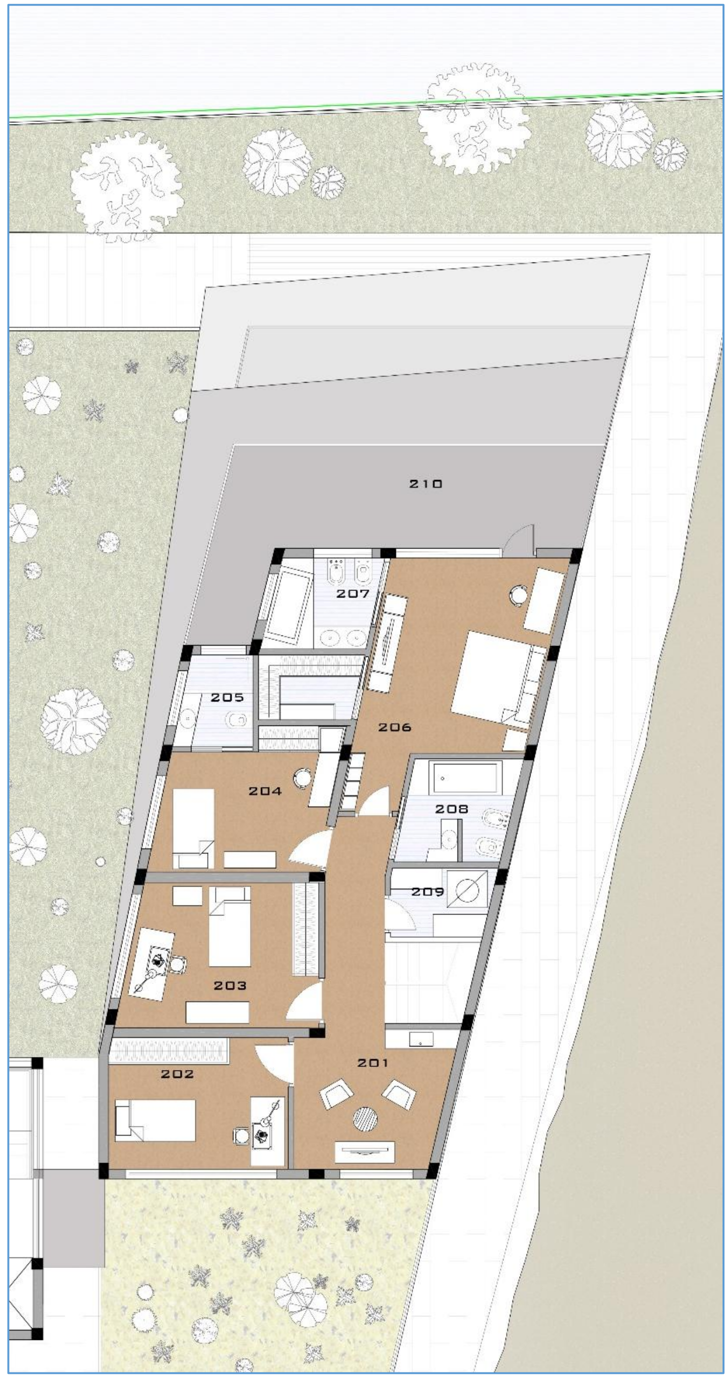




101 Guest Room	102 Kitchen	103 Living Room	104 Guest Toilet	105 Storage
201 Living Room	202 Nedroom	203 Bedroom	204 Bathroom	205 Laundry
206 Master Bedroom	207 Walking wardrobe		Area : 147 + 130 = 277 m^2	

3.6.3 Unit 4 :





101 Guest Room	102 Kitchen	103 Living Room	104 Guest Toilet		105 Storage
201 Living Room	202 Bedroom	203 Bedroom	204 bedrrom		205 batrooj
206 Master Bedroom	207 bathroom	208 bathroom	209 laundry		Area: 155 + 180 = 335 m^2

3.7 Drawings and renders:

In the plan the section lines are seen and in the following pages the section and elevations are presented:

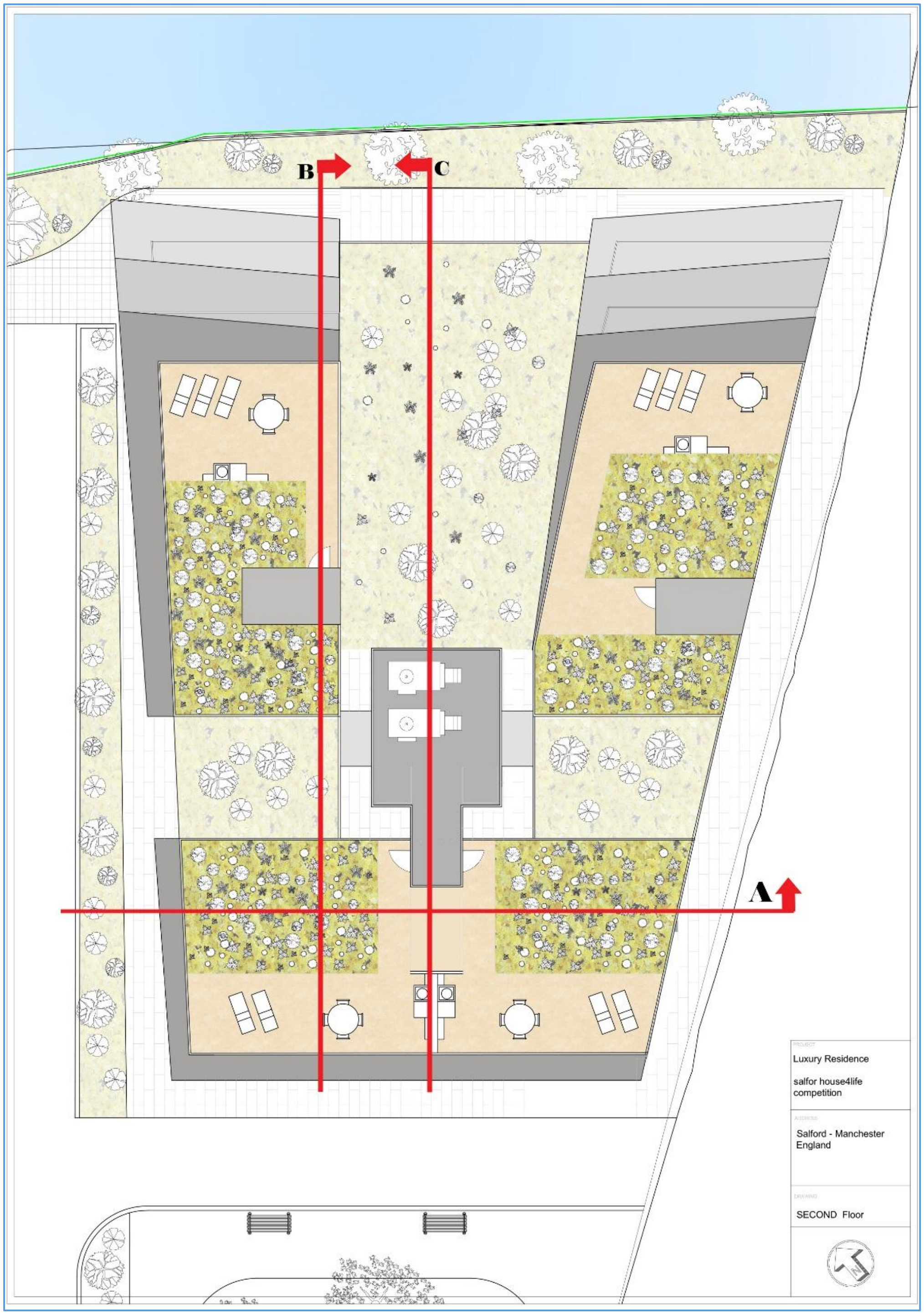


Figure 129 Section Lines

3.6.1 Elevations:

North Elevation:

South Elevation:

Easr Elevation:

West Elevation:

3.7.2 Sections

Section A-A

Section B-B

under ground
-400
ground floor
0
first floor
450
second floor
780
roof
1110
top roof
1480

Section C-C


under ground
-400
ground floor
0
first floor
450
second floor
780
roof
1110
top roof
1480

3.7.3 Renders

TECHNOLOGICAL DESIGN

chapter 4

MASTER OF ARCHITECTURAL ENGINEERING – THESIS REPORT

4. Technological Design:

4.0 Vision

As the project is located in Salfrod, England, it is necessary to be aware that the energy policy of UK and their guidelines and codes for green building, as well as those requested by European Union which ought to be followed and obeyed.

4.0.1 EU Strategy

The Europe 2020 strategy is about delivering growth that is: smart, through more effective investments in education, research and innovation; sustainable, thanks to a decisive move towards a low-carbon economy; and inclusive, with a strong emphasis on job creation and poverty reduction. The strategy is focused on five ambitious goals in the areas of employment, innovation, education, poverty reduction and climate/energy.

To ensure that the Europe 2020 strategy delivers, a strong and effective system of economic has been set up to coordinate policy actions between the EU and national levels.

The climate and energy package is a set of binding legislation which aims to ensure the European Union meets its ambitious climate and energy targets for 2020.

These targets, known as the "20-20-20" targets, set three key objectives for 2020:

A 20% reduction in EU greenhouse gas emissions from 1990 levels;

Raising the share of EU energy consumption produced from renewable resources to 20%;

A 20% improvement in the EU's energy efficiency.

In Europe, buildings (homes + tertiary) contribute for the 40.7%to global energy consumption. EU points out that the building sector has significant room for improving energy efficiency.

Take a look at the energy use in household; it is easy to realize the vast energy used during the life of the building is for space heating and domestic hot water (DHW)

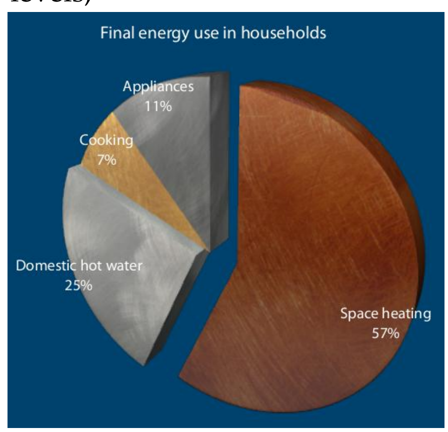


Figure 130 househeld energy use

4.0.2 Competition specific requirements:

The scheme should be an exemplar project, showcasing the feasibility of achieving maximum energy efficiency and zero carbon status via sustainable design initiatives, construction techniques and integration of renewable energy technologies.

4.0.3 Informatics support:

Having talked about these regulations and guidelines, it is important to see the building as a complex system and design a comprehensive strategies.

To do so we have adopted a model defined in Revit which will be the base of all our energy calculation and will be the center of our BIM based system which greatly helps us to do measures in different areas.

4.1.1 Geo Climate of Site area

At 53°28′59″N 2°17′35″W (53.483°, −2.2931°), and 205 miles (330 km) northwest of central London, Salford stands about 177 feet (54 m) above sea level, on relatively flat ground to the west of a meander of the River Irwell – the city's main topographical feature. In 1904 Salford was recorded as "within a great loop of the River Irwell roughly three quarters of a mile from north to south and one mile from east to west". [68]

Salford is located on the Northern Hemisphere of the Earth. Therefore, it can be said that winter lasts from the winter solstice to the vernal equinox (typically March 20), while summer lasts from the summer solstice through to the autumnal equinox (typically September 21)"[69] .

As our building site has an orientation towards north-west and the structure covers a large area of project field, it was not much flexible to manipulate the orientation of the building, but to think of a number of strategies to make best of the natural energy possibilities and a number of energy saving applications, so deliver a high-efficient building which will be further discussed in following chapters.

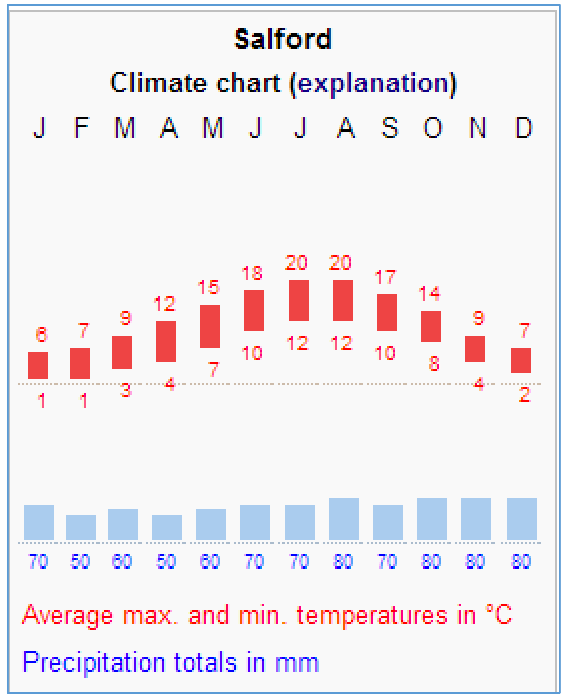


Figure 131 Climate Chart , Yahoo Climate 2008

4.1.2 Sun Path Diagram:

A Sunpath Diagram is a very simple tool to illustrate the continuous changes in solar geometry for a location via a 2-dimensional chart.

In a Sunpath Diagram, the solar position is immediately defined, at every time of the day and day of the year, by the reading of its azimuth and altitude angles.

The azimuth represents the horizontal angle that the projection of the Sun's position makes with North;

the altitude illustrates the vertical angle that the Sun makes with the horizon.

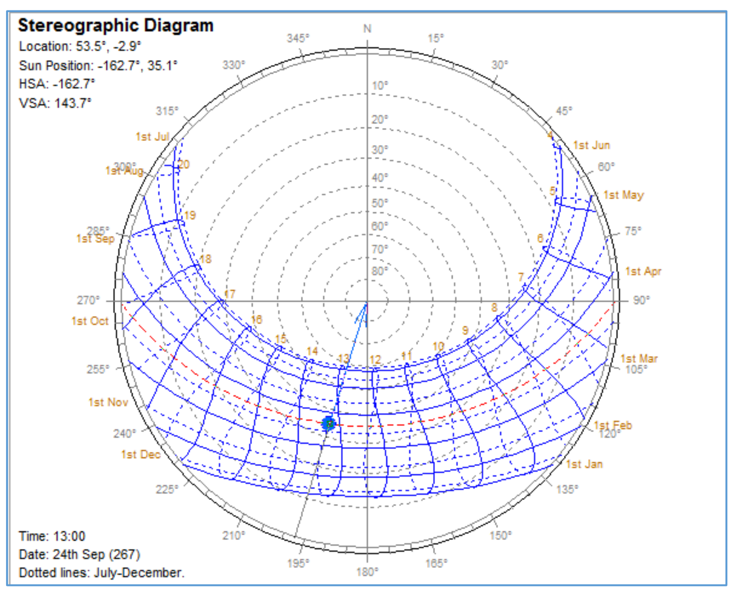


Figure 132 sun path diagram from Ecotect

---

[68] *Global Gazetteer, Version 2.1* (Falling Rain Genomics, Inc), retrieved 22 January 2009

[69] Wikepedia

Sunpath diagrams constitute therefore a convenient way for designers to ascertain solar access and shading requirements for a given location and for a specific time of the year. [70]
The position of the sun and its relation with our building has a great effect on sola heat gains and subsequently on thermal comfort and energy consumption. Also in term of natural lighting in order to obtain a higher quality of interiors, was very essential in our design.
A great area of the facades are made of larger windows which according to their position to sun, necessary shading have been applied to the building, where more significantly are the ones facing east south to west south which may absorb excessive solar gains if not prevented an efficient shading system which in our case, the concrete slabs prolonging form building sides, are also working as the shading system which later will be further discussed.

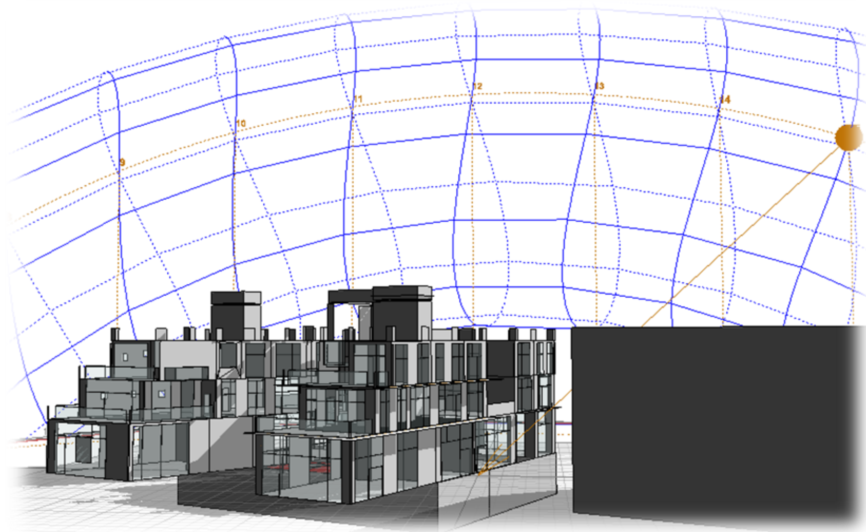


Figure 133 3D sunpath , shadows on april .15:00

4.1.3 Temperature

Temperature is a one the parameters measured to give us information about climate of an area, and has some great advantages as it is easily measured, it is understood by almost every body and it gives very quick information of what you might expect of climate of a region.
going into a more scientific definition, A convenient operational definition of temperature is that it is a measure of the average translational kinetic energy associated with the disordered microscopic motion of atoms and molecules. The flow of heat is from a high temperature region toward a lower temperature region. The details of the relationship to molecular motion are described in kinetic theory. The temperature defined from kinetic theory is called the kinetic temperature. Temperature is not directly proportional to internal energy since temperature measures only the kinetic energy part of the internal energy, so two objects with the same temperature do not in general have the same internal energy (see water-metal example). Temperatures are measured in one of the three standard temperature scales (Celsius, Kelvin, and Fahrenheit).[71]

$$\left[\frac{1}{2}mv^2\right]_{average} = \frac{3}{2}kT$$

defines the kinetic temperature

k = Boltzmann constant

Temperature at a specific location is influenced by several factors;

- Topographic features of the area (altitude above sea level, depressions, etc.)

[70] www.educate-sustainability.eu
[71] http://hyperphysics.phy-astr.gsu.edu

- Factors related to the surface (vegetation and geology of the ground)

- Location (rural or urban)

- Exposure to sun

- Movement of air (presence or absence of wind)

- Cloudiness

Also the following information is inevitable to establish the site specific climate features

- Monthly Average Temperature (Calculated on the basis of data obtained throughout a sufficiently long period)

- Monthly Average Value of Temperature Difference between the Lowest and Highest Temperatures in 24 hours (Calculated on the basis of data obtained throughout a sufficiently long period)

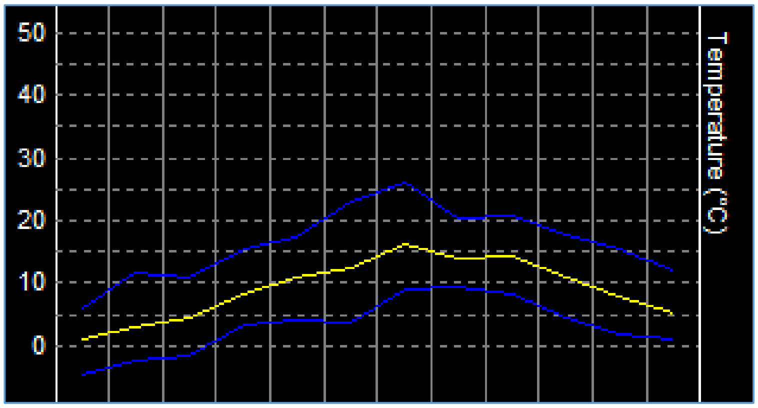


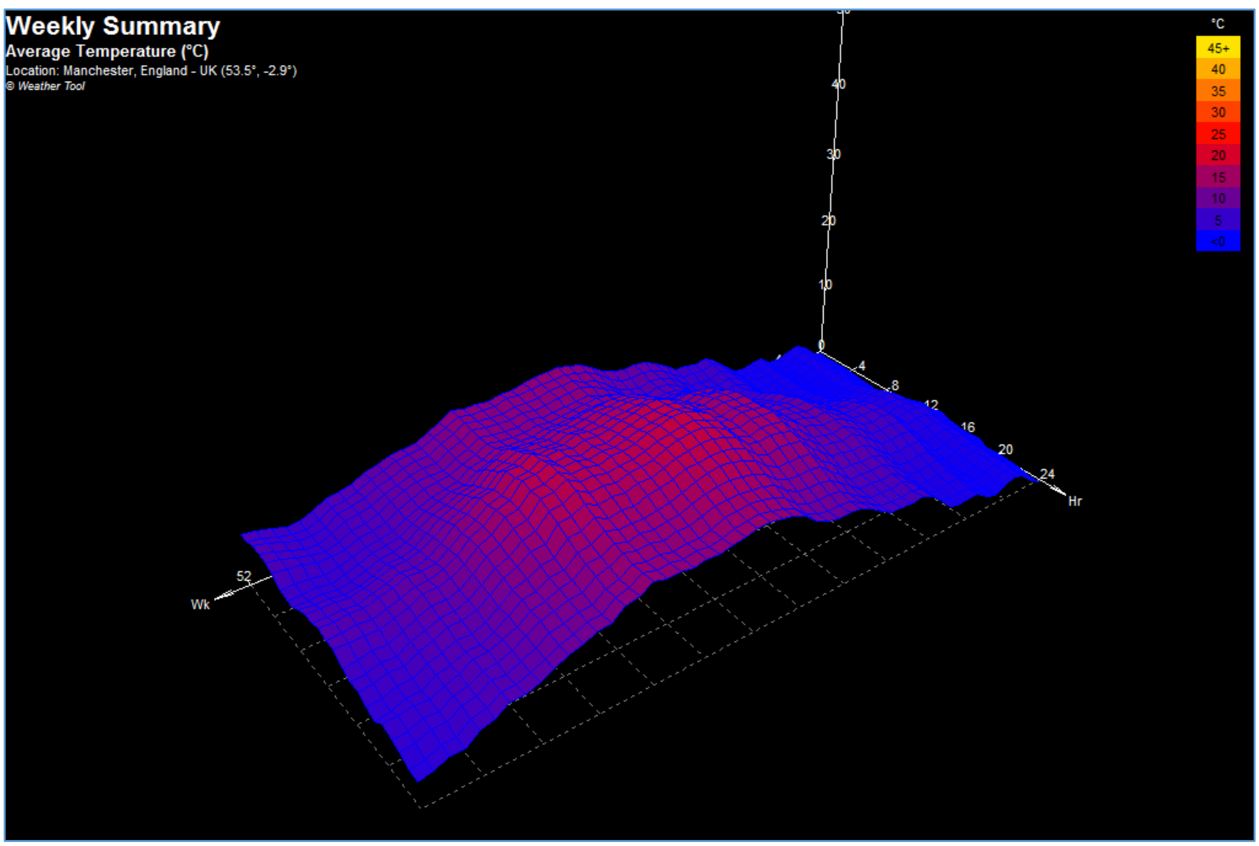
Figure 134 average monthly temp. data from Ecotect Weathertool

MONTHLY DATA

	Avg.Temp. (°C)
Jan	1.3
Feb	2.9
Mar	4.6
Apr	8.2
May	11.0
Jun	12.6
Jul	16.1
Aug	14.1
Sep	14.5
Oct	11.0
Nov	8.0
Dec	5.4

As displayed above, from the information provided by Ecotect weather tool specified for Manchester city about the average monthly temperature through the year, no extremely cold winters or hot summers are usually expected.

We can further study also the weekly average temperature and obtain more detailed



information about temperature differences during the day and short periods. We still used Ecotect weather tool to obtain a 3D graph showing the weekly temperature average:

As observed from the graph, there is not a huge difference during different seasons between a 24hour day temperature. Especially during colder months of the year. During the weeks that the temperature is between 0-15 supply of heating is applicable. Also between weeks 34 to 36 we can experience high temperatures and a cooling load might be necessary.

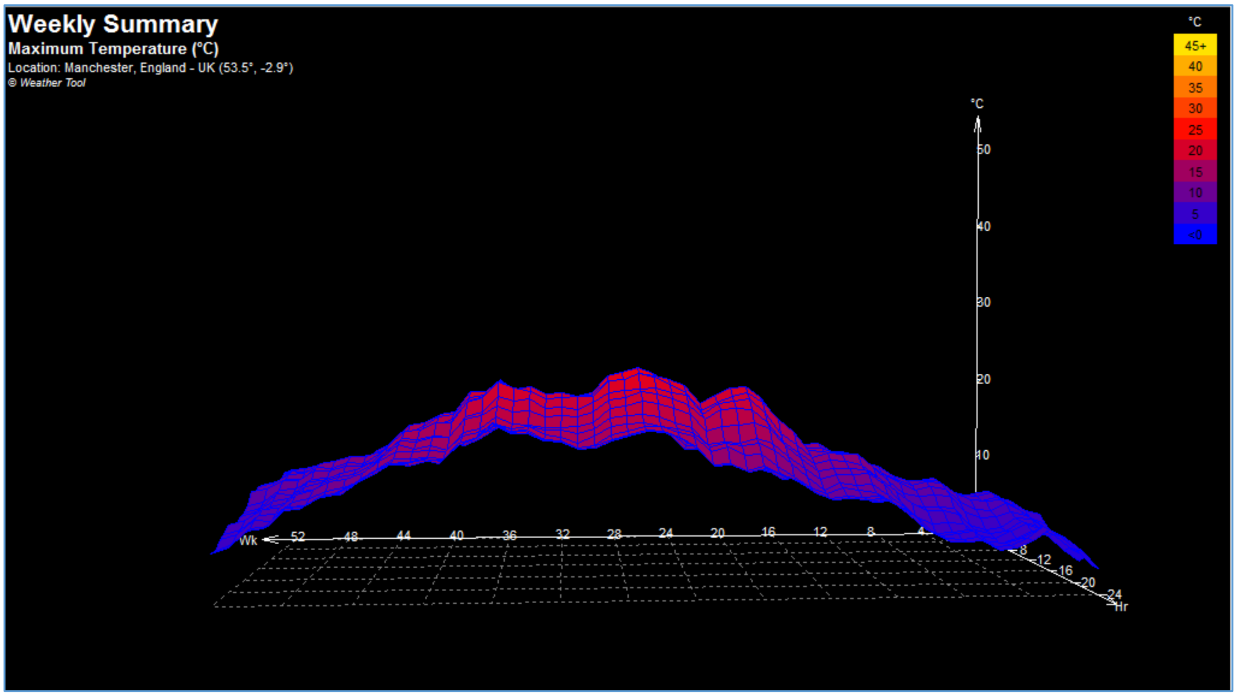


Figure 135 maximum weekly temperature

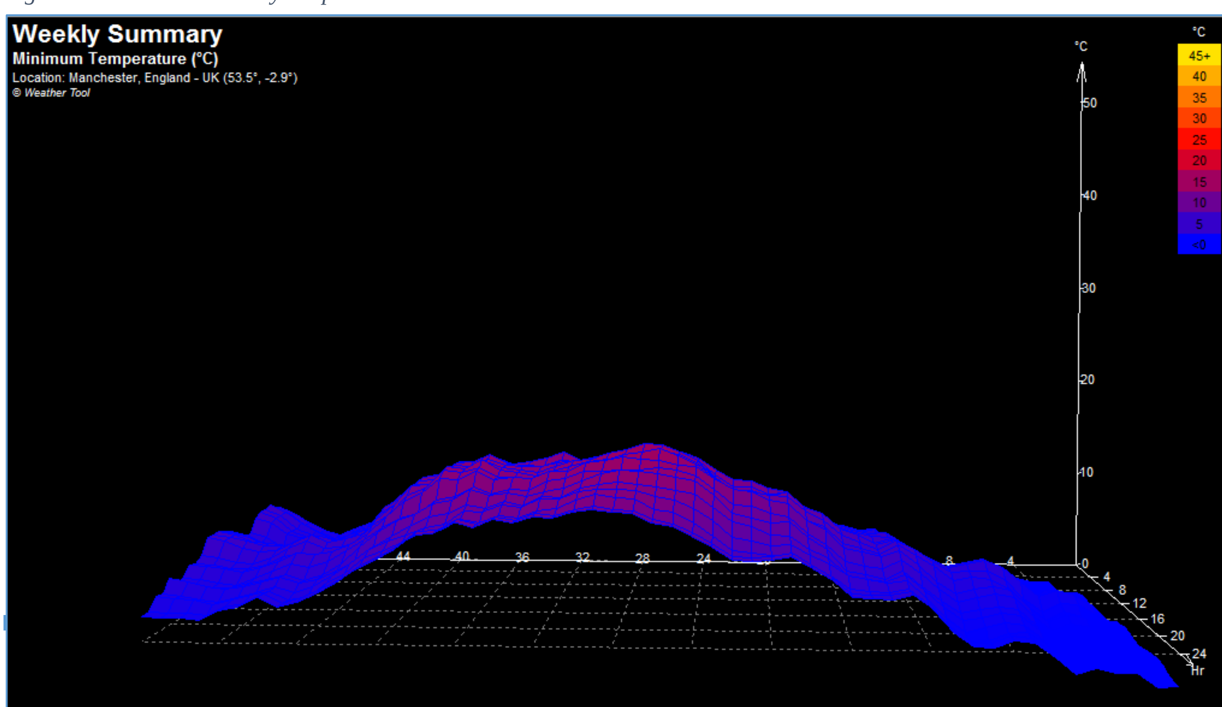
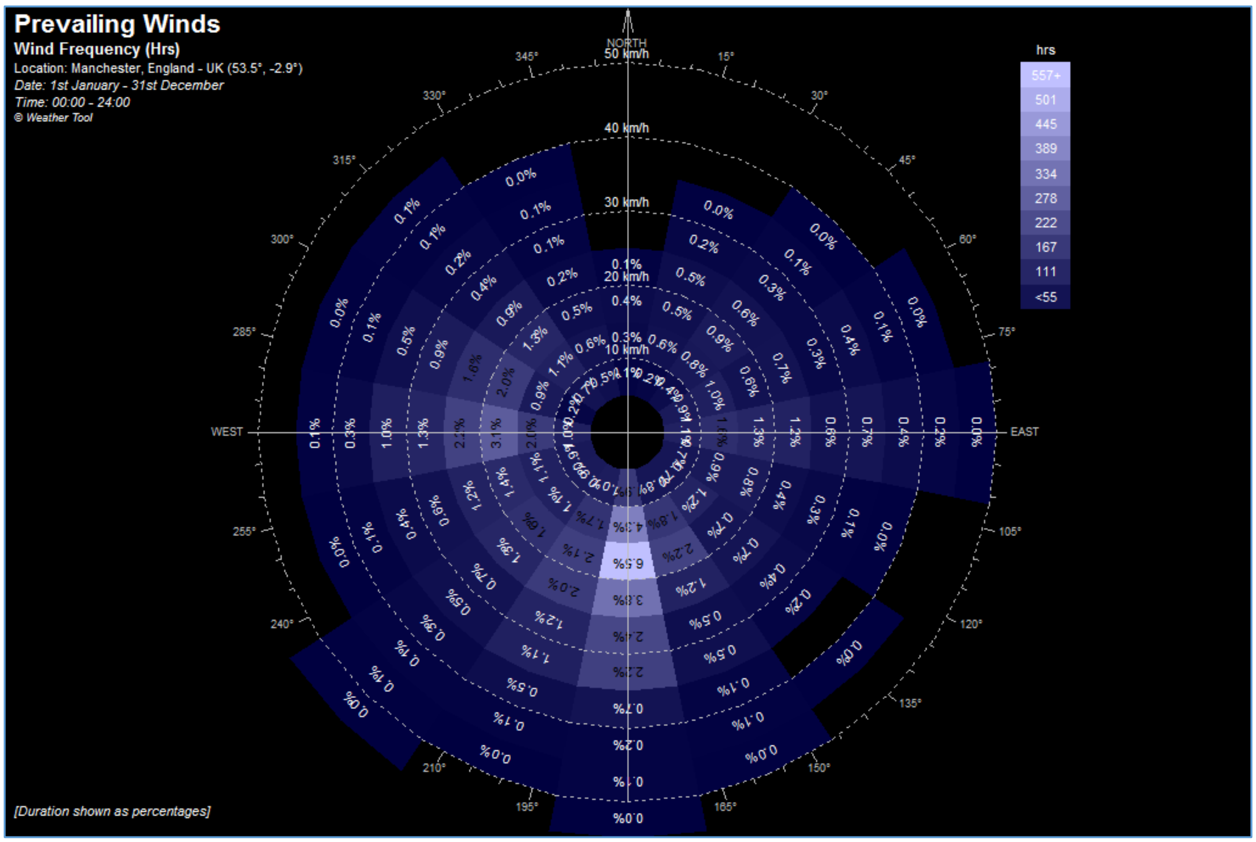


Figure 136 minimum weekly temperature

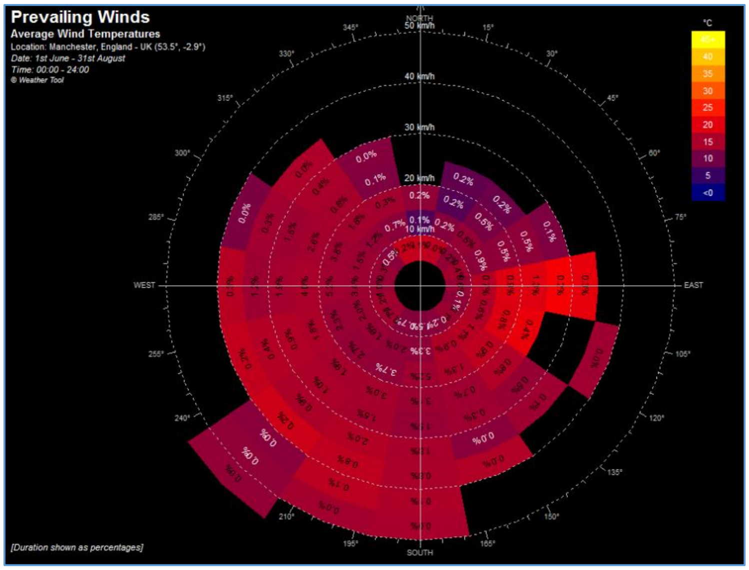
4.1.4 Wind

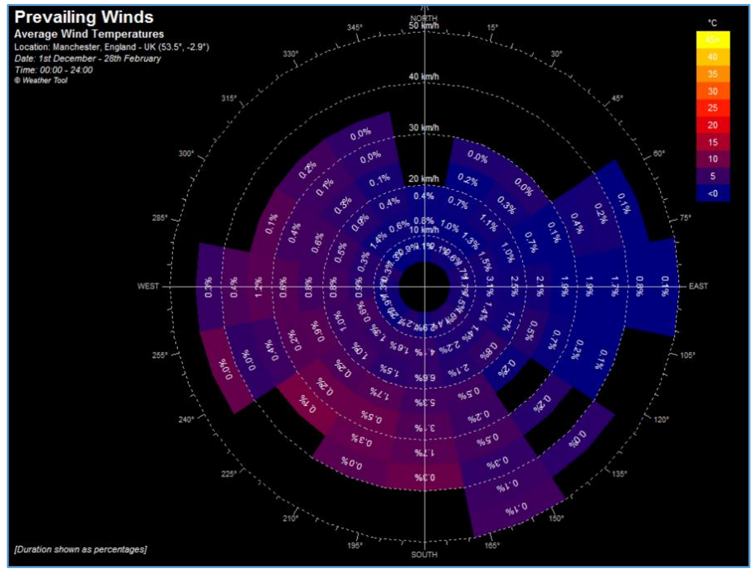
The speed and direction of wind could need great consideration in a building design, especially for the high rise ones. The smart and proper use of wind by the building orientation, could help passive air ventilation and help increase the quality of space.
The World Meteorlogical Organization (WMO) sets the recommended standards for meteorological measurements. The NWS defines a wind gust as "the maximum instantaneous speed in knots in the past 10 minutes ..." (when there is a rapid fluctuation "in wind speed with a variation of 10 knots or more between peaks and lulls.") And wind speed is defined as the "2-minute average speed in knots ..." [72]
Sustained wind speeds are reported globally at a 10 meters (33 ft) height and are averaged over a 10 minute time frame. In this study, the wind speeds are given in m/s and km/h.



As seen the graph above which reprensts the wind frequency through ou t the year on basis of hours of blow, we can see that wind blown in from south and south west through north have a great frequency and according to the orientation of the building, this can increase the efficiency of natural ventilation strategies.

[72] http://iridl.ldeo.columbia.edu





Observing the two graphs above provided by Ecotect weather tool, we can see that during winter cold winds by east have high frequency with high speeds. Fortunately our building being positioned beside the train track, on its east façade has the minimum openings and could be even protected by the train track.

In summer winds blowing has mainly a temperature between 5 to 20 degrees and as can be seen from south and south west we have more frequent wind with higher speeds which are pleasant as natural ventilation and all the units in the building may enjoy it. As seen in the graph below, it appears that during the middle hours of the day , we have higher speed of wind, which in summer it is even higher which might be helpful for the hot hours of hot months to benefit from cooling ventilation.

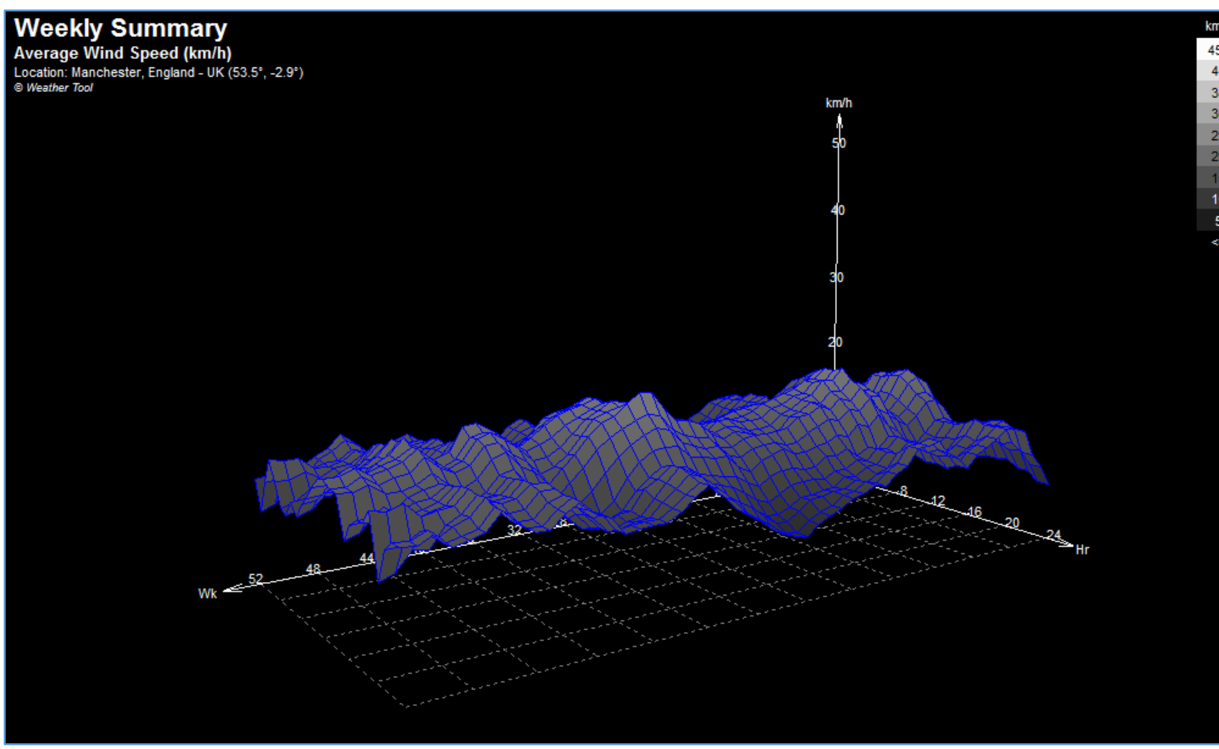


Figure 139 weekly avg. wind speed

4.1.5 PRECIPITATION

Precipitation is defined as "any product of the condensation of atmospheric water vapor" that falls down on Earth. Manchester receives on average 799 mm (31.5 in) of precipitation annually or 67 mm (2.6 in) each month. The month with the driest weather is March when on balance 45 mm (1.8 in) of rainfall (precipitation) occurs. The month with the wettest weather is August when on balance 81 mm (3.2 in) of rainfall (precipitation) occurs. It is important in sense of the way people percept their city as in rainy days the urban atmosphere changes also and it is important to see if the rainfall is high enough to make efficient to propose some water collecting system for the project.

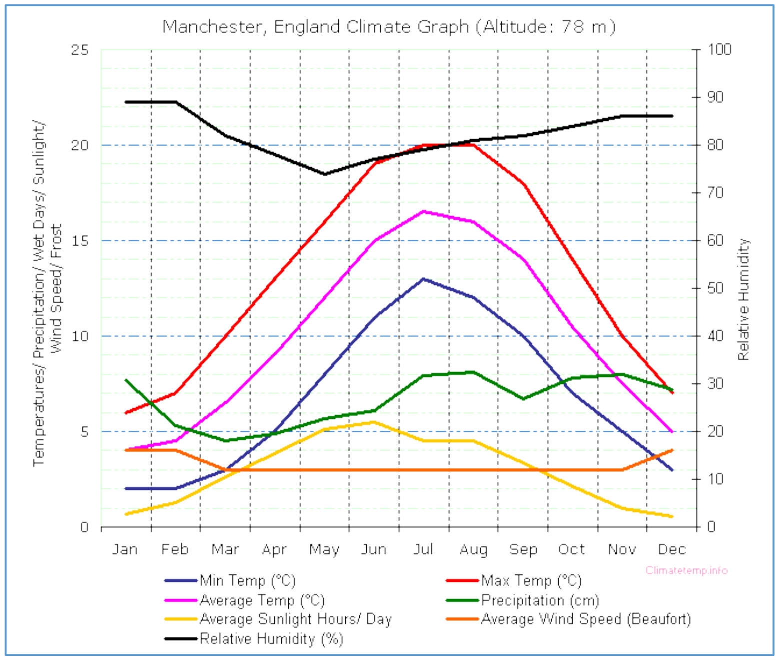


Figure 140 some climate average data

4.1.6 Relative humidity

The humidity in the air of our homes contributes considerably to both our health and our comfort. This discussion will cover the moisture in the air, its benefits, factors affecting it, how to measure it, and how to maintain a satisfactory amount of moisture in the air.

Moisture in the air is called humidity.

The humidity or moisture level is measured as relative humidity (R.H.) Air at 100 percent relative humidity contains all the moisture vapor it can hold. [73]

Implementing HVAC system in the building, it is essential to maintain the relative humidity within an acceptable range, to guarantee the comfort feeling.

Usually relative humidity between 30% and 70% is accepted as comfortable.

As seen in figure 17 , from October to February the relative humidity is above the acceptable comfort level and the need to be treated by the HVAC systems designed for the building located in Salford.

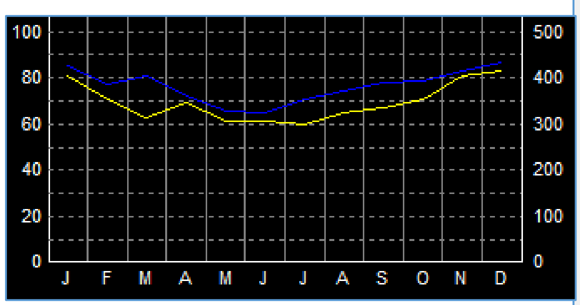


Figure 141 RH at 3 p.m trhough the year

MONTHLY DATA

RH 3pm (%)	
Jan	81
Feb	71
Mar	63
Apr	69
May	61
Jun	61
Jul	60
Aug	65
Sep	67
Oct	71
Nov	81
Dec	83

Looking at the Relative Humidity weekly summery , and noticing the Z axis where RH as

73

displayed, we can see the high percentage of RH in winter months and looking at the hours of the day, we see that during the middle day of middle of the year, we have the lowest level of relative humidity.

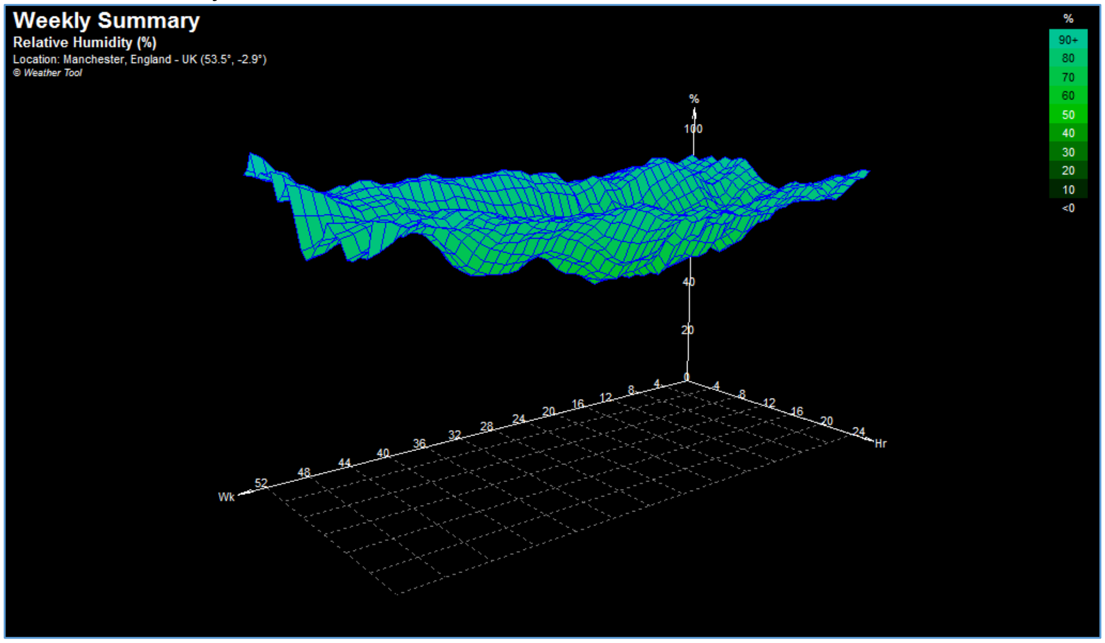


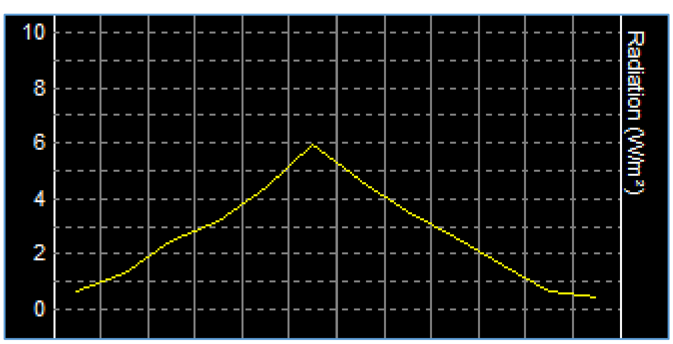
Figure 142 weekly relative humidity

4.1.7 SOLAR RADIATION

Hours of sunshine range between 0.5 hours per day in December and 5.5 hours per day in June. On balance there are 1071 sunshine hours annually and approximately 2.9 sunlight hours for each day in Salford. As seen in the graph below from November to January the solar radiation rate is quite low and it may be important while deciding for Solar energy based system for hot water or for electricity.

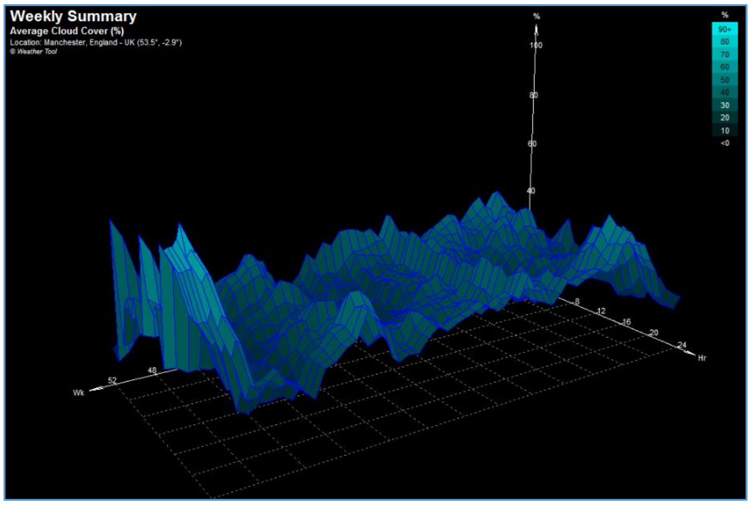
Having a look at the weekly summary graph it is quickly observed the difference between direct solar radiation during different monthof the year and it is very low amount in winter.

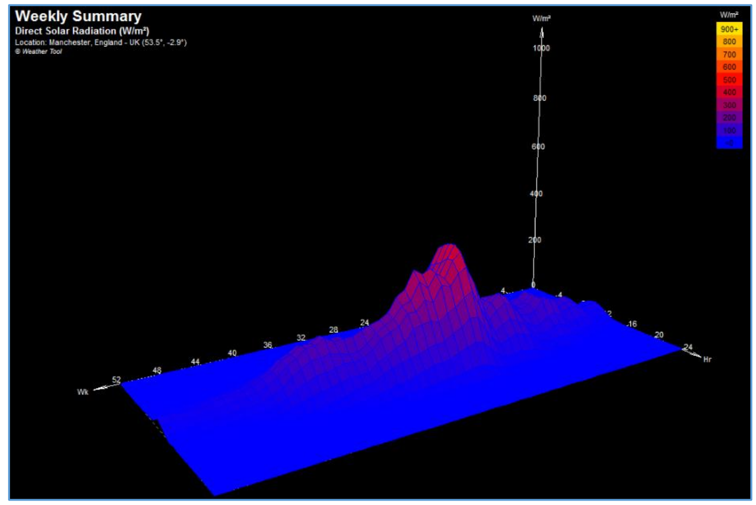
If we have a look at cloud analysis it may be obvious where the differences come from.



MONTHLY DATA	
	Sol.Rad.(Wh/m²)
Jan	667
Feb	1318
Mar	2429
Apr	3185
May	4379
Jun	5964
Jul	4645
Aug	3539
Sep	2634
Oct	1610
Nov	629
Dec	411

As it can be seen from comparing these two graphs, the direct relation between the amount of cloud and direct solar radiation, where the cloudiest weeks of the year are the last ones which correspond to those with lowest solar radiation.





4.1.8 Thermal comfort

Thermal comfort is defined in British Standard BS EN ISO 7730 as:
'that condition of mind which expresses satisfaction with the thermal environment.'
So the term 'thermal comfort' describes a person's psychological state of mind and is usually referred to in terms of whether someone is feeling too hot or too cold.[74]
The most important environmental factors contributing to thermal comfort are:

- air temperature
- radiant temperature (ie. the temperature of the walls, floor, windows etc)
- humidity
- air speed
- the amount of physical activity
- the amount and type of clothing worn.

The recommended temperature range to optimize indoor thermal comfort for most people is 19°C to 28°C [75]. This temperature range is appropriate for the sedentary or near sedentary physical activity levels.

[74] http://www.hse.gov.uk/
[75] ANSI/ASHRAE Standard 55-2004: 'Thermal environmental conditions for human occupancy'

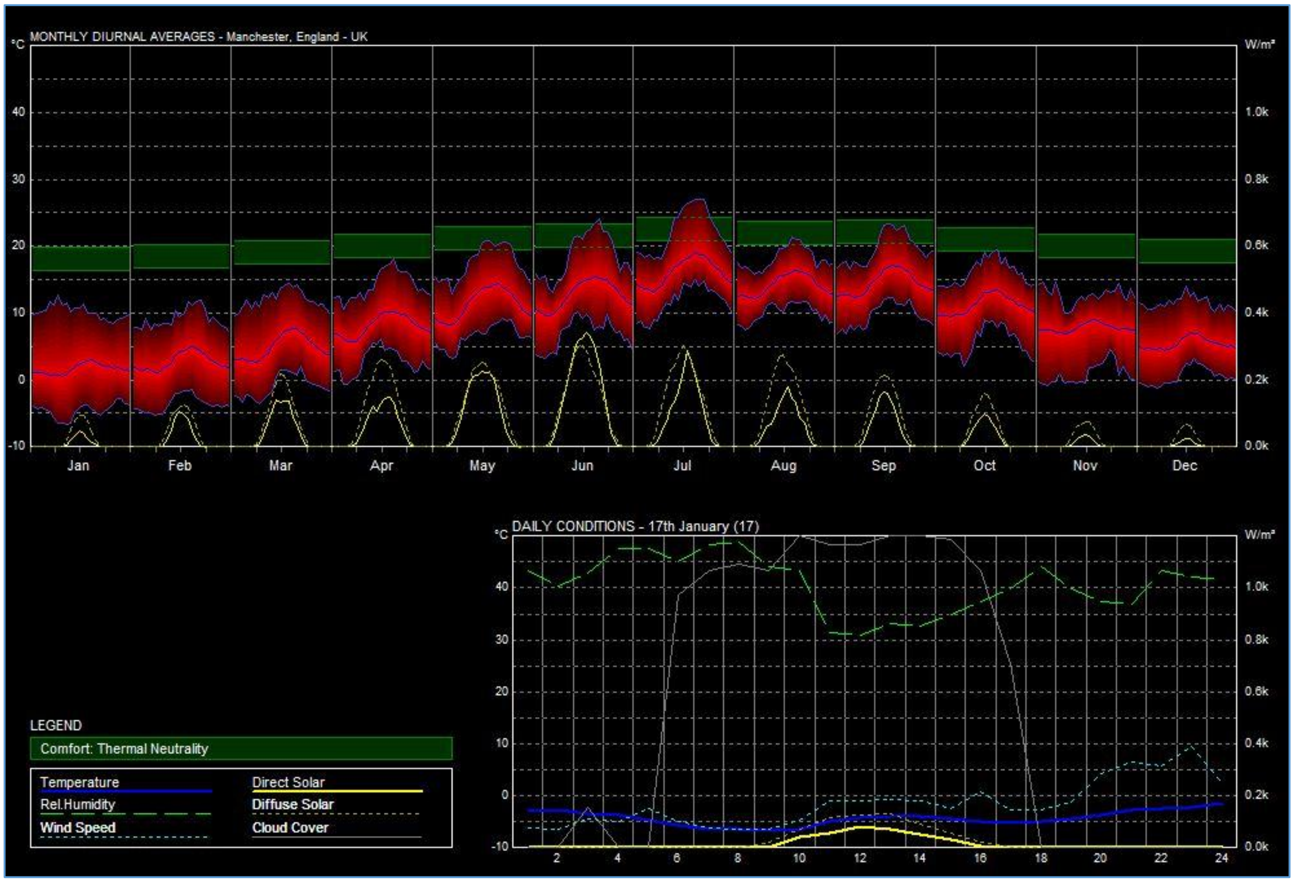


Figure 143 Summer Peak

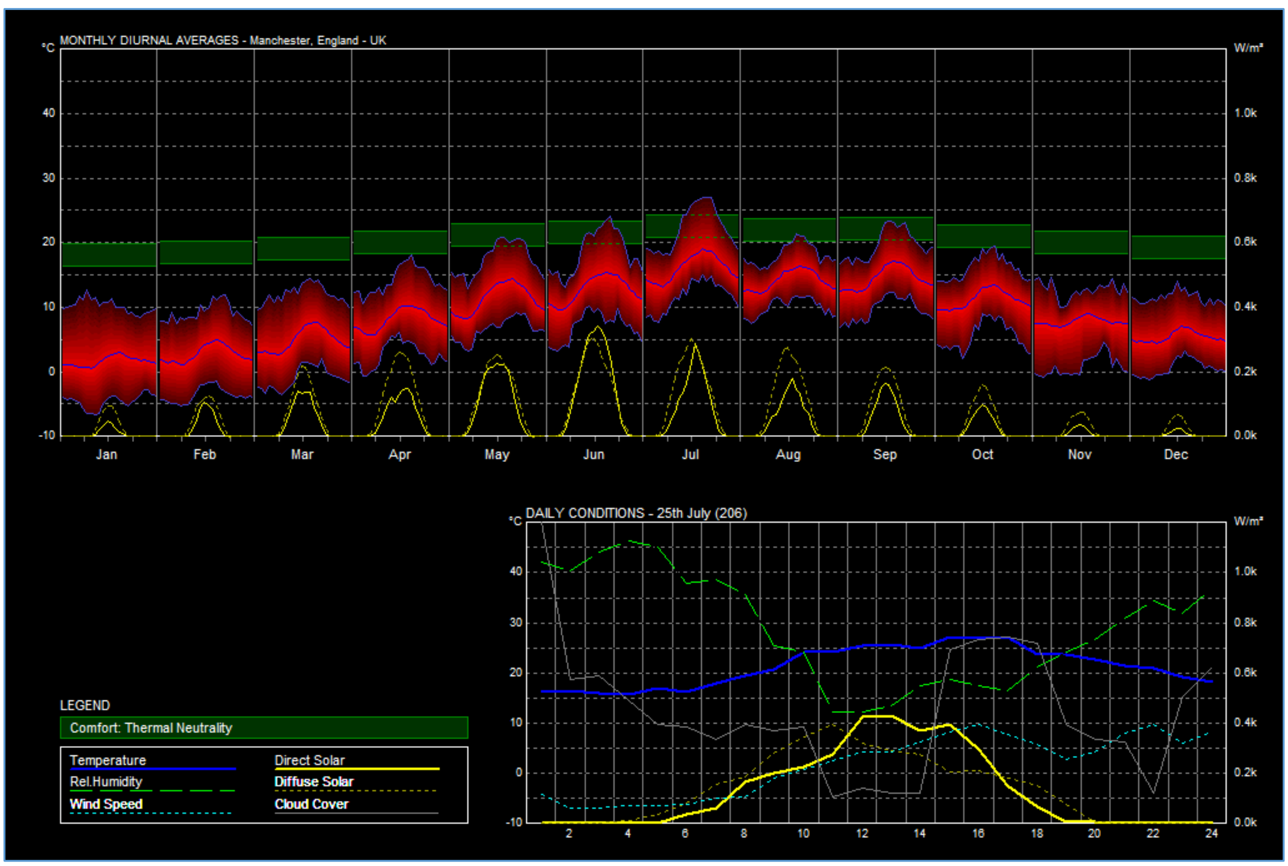


Figure 144 Coldest Peak

The weather data is demonstrates a brief based on the summer and winter peaks that occur on the 25thJuly and 17th of January respectively. The graphs above show the maximum, minimum and average monthly temperatures in Manchester which is very close the conditions of Salford. In addition to that the dotted green line shows the relative humidity while the solid green area shows the comfort zones for the particular months. The graphs on the bottom right hand corner show the daily details for the summer peak, 25th of July and for the winter peak, 17th of January. The figures also tell that from November through March heating is required.
Now we shift our focus to the Psychometric charts that show us a comfort band that we shall assay to achieve through our designs. The psychometric chart shows graphically the parameters relating to water moisture in air. This application note describes the purpose and use of the psychrometric chart as it affects the HVAC engineer or technician.

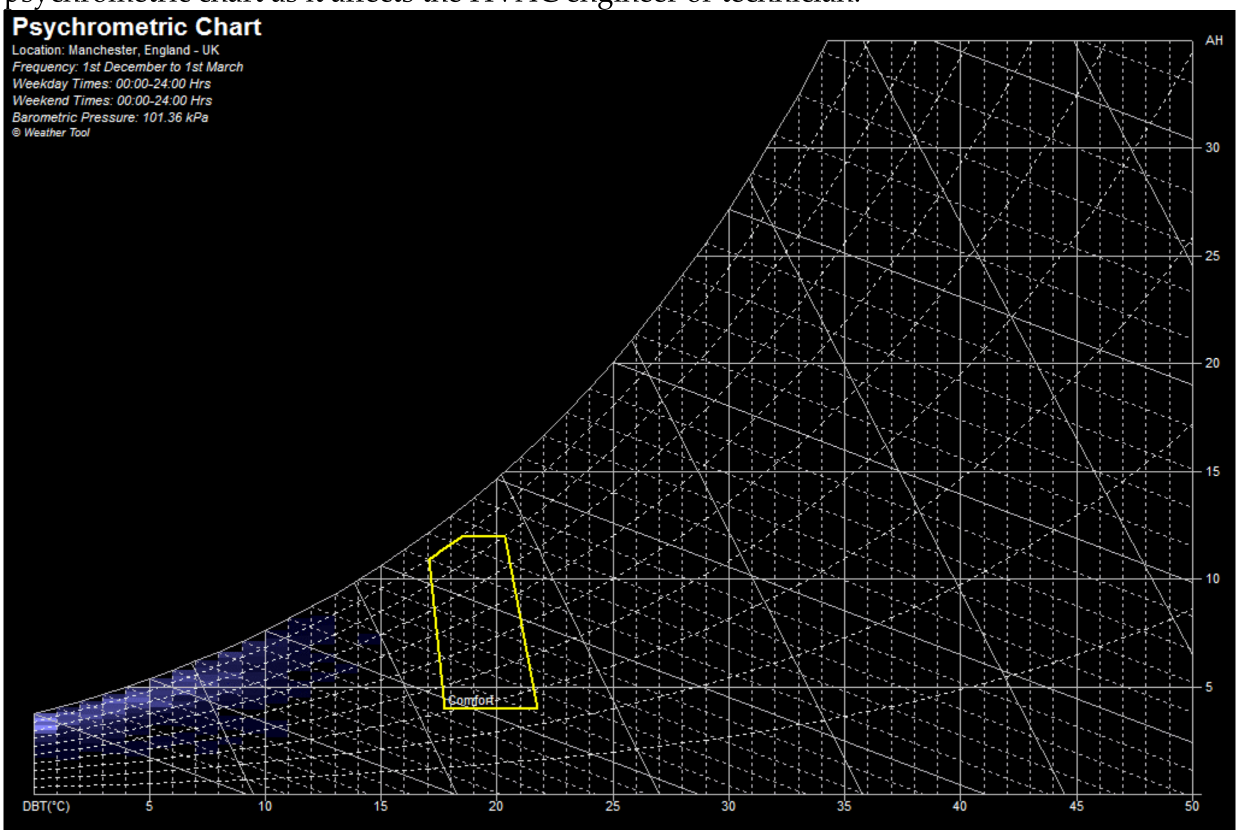
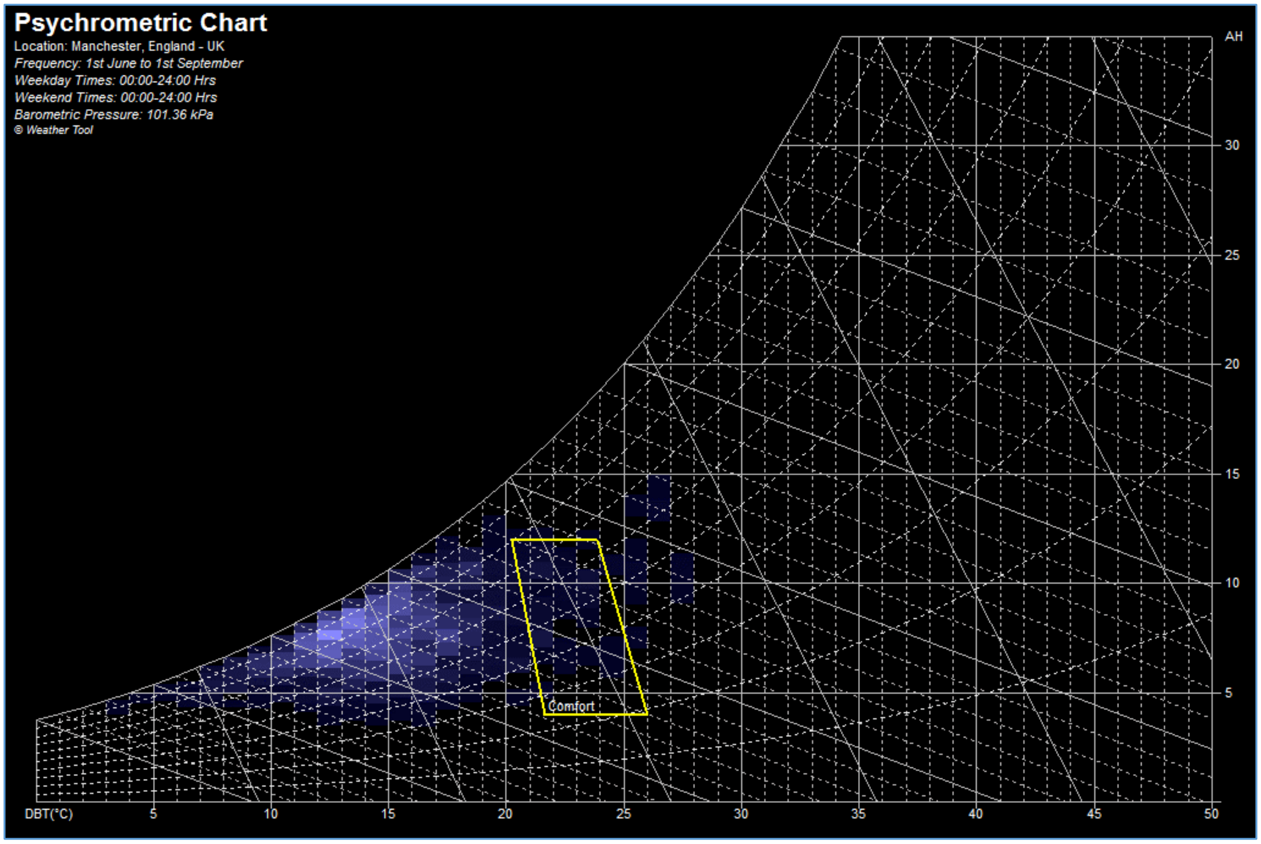


Figure 145 winter comfort zone

The yellow square in this figure and the next one shows us where the comfort level settles in winter and summer conditions. About figure 21, the winter comfort zone the cumulative frequency for temperature fall down below the comfort band and the relative humidity on the other hand stays above the comfort level at around 80 to 90 %. Therefore in winter we are required to heat the incoming air while also at the same time dehumidify it to the required level.



From the summer comfort zone it is clear that the cumulative frequency of the temperature remains between 10and 20 °C and the relative humidity also remains inside the comfort zone with 60 to 70 % for the most days of the summer. This indicates summer doesn't require usually cooling loads and with dehumidification during few days is required.

4.2 BIM and ICT integrated design

there are some promising emerging ICT enabled approaches, e.g. Building Information Modelling (BIM), which could support a comprehensive digital representation of all construction information for various stages of the project lifecycle. Moreover, BIM adoption could also enhance team collaboration, project integration, construction information flow, documentation, and teamwork planning and coordination.[76]
Observing the IT companies involved in field, Autodesk being a prominent one, it is obvious that there is a lot going on for developing new tools such as its newly introduced BIM in cloud system with its platform Cloud360 along with management suites such as Navisworks and Constructware and BIM tools like Revit, improves Clash detection, coordination, and collaboration, Conceptual design and feasibility evaluation, Field management, commissioning and etc.

[76] Jack Goulding1, Farzad Pour Rahimian, Mohammed Arif, and Mark Sharp: Offsite contruction: Strategic priorities for shaping the future research agenda. doi:10.5618/arch.2012.v1.n1.7

During the development of our design, we started to adopt our project in BIM based system. The software used for modeling was Autodesk Revit ®, in which we created a model that was the basis of the further develpments for our project. Following we see some advantages of employing a BIM based system.

4.2.1 Design and Visualization

after the conceptual design stage, we drew the plans in autocad. This cad file was imported as linked file, meaning that any further modifacations on the drawing shall be automaticly updated in Revit, this is a great feature where different people and companies work on the same project and each can have his modification and others will have it modified.

So we started creating the model and during the work we realized its capacities even in terms of design. For example when we changed the position of a wall or size of a window, you will see the changes immediately in 3D and in elevations and sections, thus providing a great help for design decision . and the amount of time saved by these automatic updates and all relative drawings, is very considerable.

After having the model completed, we could have easily good quality renderings of the model, form interior and exterior, along with features like walking in the building, makes a great presentation tool which is a great way of communicating of ideas between different parties in the project and clients.

4.2.2 Technological solution through informatic cloud:

A great feature of BIM is that from the start of Building up the Model, we can have our technological solution integrated in it. In a way we can define the true layers of our walls, floors and ceilings which both in term of drawing visualisation and in the analysis are very important. Clash detection of a BIM model is another improtant feature which specially comes handy while integrating the HVAC and mechanical equipment and the structure of the building, into the BIM model. So if for example and air canal interferes with the structure, the program will tell us immediately and a number of errors could be prevented by this feature.

another important feature is the ability of importing different from into Revit, and exporting different formats from Revit, which could be used for furthur analysis in different software. What we did for our Ecotect analysis, we had to export an output from our model, in form of gbXNL ,which uses rooms created in Revit model, as basis for creating external putputs. The Green Building XML (gbXML) open schema helps facilitate the transfer of building properties stored in 3D building information models (BIM) to engineering analysis tools. Today, gbXML has the industry support of leading 3D BIM vendors such as Autodesk, Bentley, and Graphisoft. In addition, with the development of integration modules inside major engineering analysis tools, gbXML has become the defacto industry standard schema.

Its use dramatically streamlines the transfer of building information to and from engineering analysis tools, eliminating the need for time consuming plan take-offs. This removes a significant cost barrier to designing resource efficient buildings and specifying associated equipment.

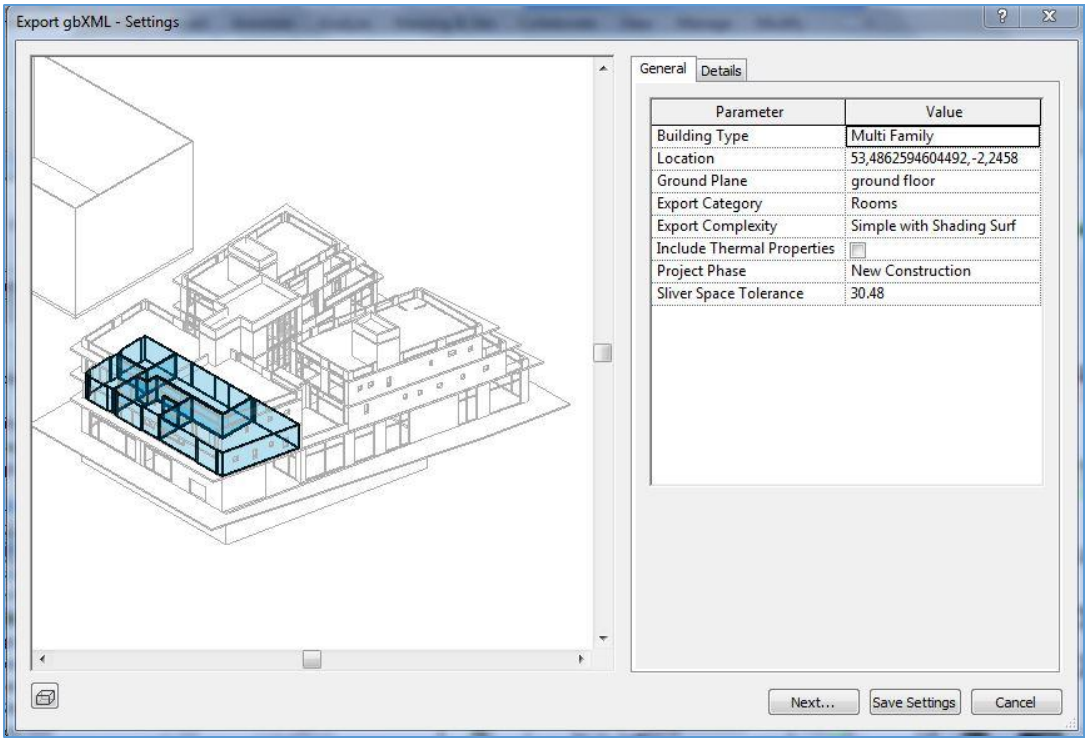


Figure 147 Revit window showing selected spaces to be exported

As seen in the image above, we chose the desired spaces for further analysis, with a complexity of Simple with shading surfaces, to achieve the gbXML output. As we were using version 2013 of Revit, ecotect does not directly import the exported gbXML file, but we had to change it format to UNICODE8 , so Ecotect could have it imported. The results were great as it gives a complete model with correct information and dimension, from which we could perform a number of analysis which later will be discussed.

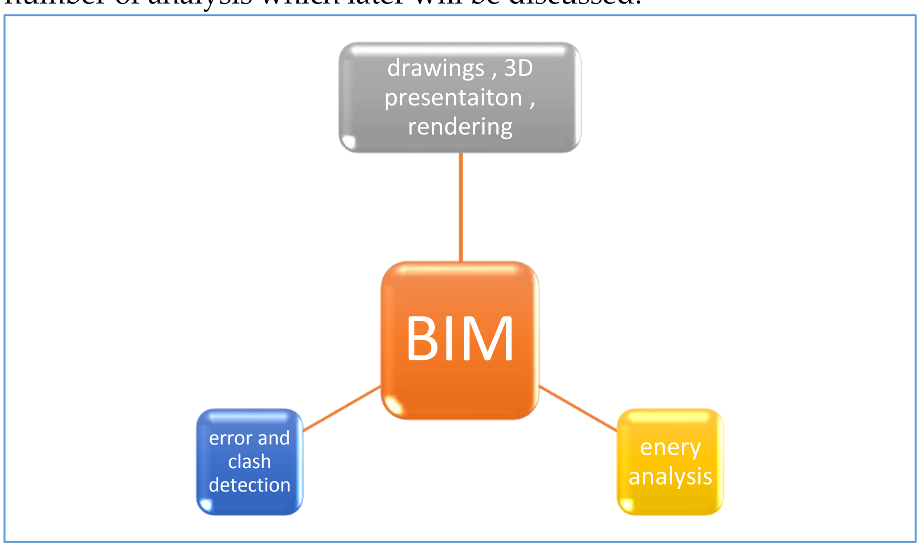
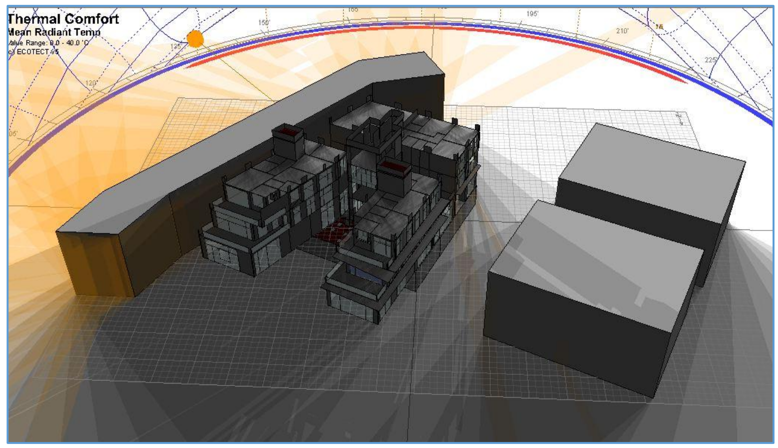


Figure 148 the chart of our integrated design

4.3 Shadow analysis

The relative position of the sun is a major factor in the heat gain of buildings and in the performance of solar energy systems. Accurate location specific knowledge of sun path and climatic conditions is essential for economic decisions about solar collector area, orientation, landscaping, summer shading, and the cost effective use of solar trackers.

In Ecotect there is also this feature to model building and blocks nearby, so we could study the effect of nearby objects on our building, and in the Urban system. With its visualization features we can see the shadow effects in a real-time system for every hour of every day of the year. In fugure 25 and 26 you can see the shadow range from 9:00 am to 17:00 during the year which has been visualized in 40 steps.



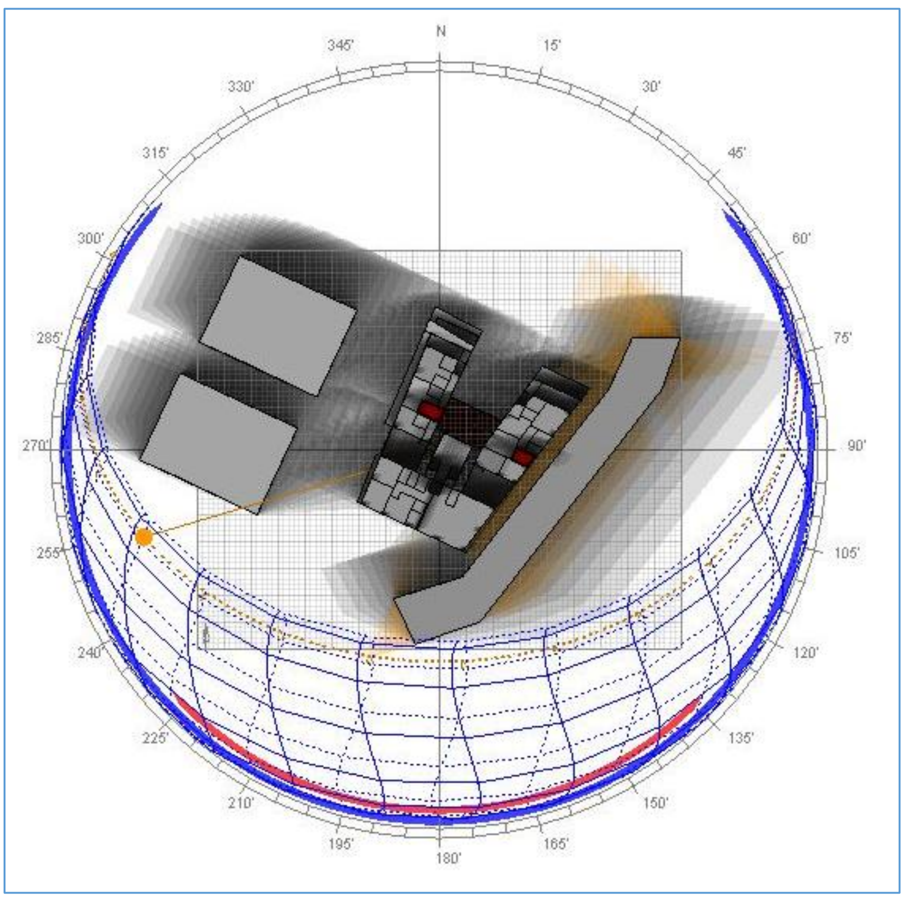
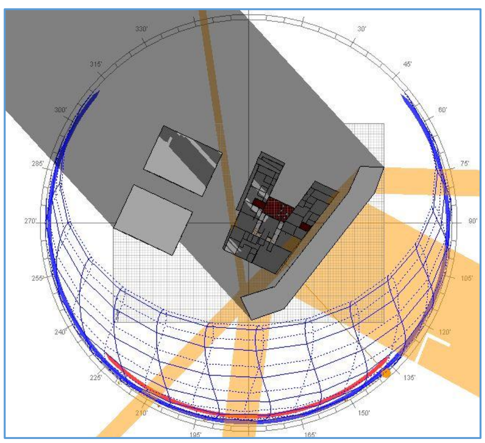


Figure 150 shadow range - plan view

4.3.1 Shadow at 09:00 am in four different seasons

Figure on left shows winter solstice on the building in the morning with sun towards northwest. It is evident that a long shadow will be formed due to lowest sun height about the horizon and the sunrays will penetrate inside the building. Winter solstice occurs on the shortest day and longest night of the year, when the sun's daily maximum elevation in the sky is the lowest. As its showing maximum shadow so its mean maximum solar radiation are entering the building which will be really good in winter.

20th December winter solstice 09:00am



20th June summer solstice 09:00am

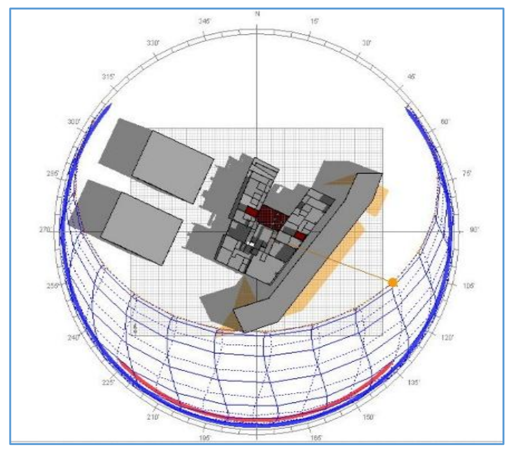
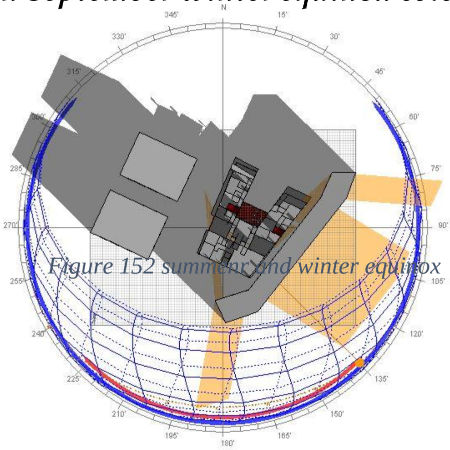


Figure 151summer and winter solstice

Figure on right shows summer solstice on the building in the morning with sun towards western. However, contrary to winter solstice the sun is at the highest point about the horizon and the sun rays will be almost perpendicular to the building so the shadow will be very short as shown in the figure. Summer solstice is the longest day of the year with maximum sun exposure.

20th September winter equinox 09:00am



20th March summer equinox 09:00am

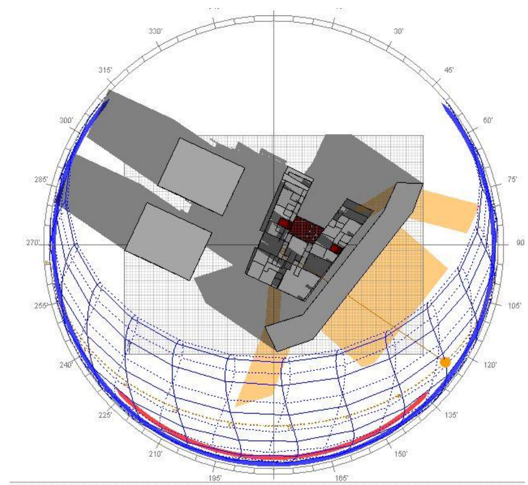


Figure 152 summer and winter equinox

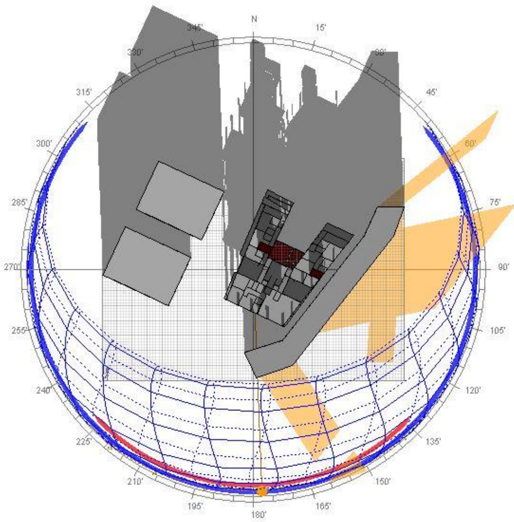
The figures above show September and March equinox respectively. The Southward equinox (or September equinox) is the moment when the sun appears to cross the celestial equator, heading southward. Due to differences between the calendar year and the tropical year, the Southward equinox can occur at any time from the 22nd to the 24th day of September.

The Northward equinox (or March equinox) is the equinox on the earth when the Sun appears to cross the celestial equator, heading northward. The Northward equinox is known as the vernal equinox in the Northern Hemisphere, and the autumnal equinox in the Southern Hemisphere.

At the equinox, the sun rises directly in the east and sets directly in the west that's why the shadow diagrams are almost similar.as seen from all the figures presented here, the right side of the building adjacent to the train track, at this hour of the year almost in all the seasons is covered by the shadow made by the train track, that is why no shading was proposed on this façade which is orientated towards South-East.

4.3.2 Shadow at 12:00 pm in four different seasons

20th December winter solstice 12:00pm



20th June summer solstice 12:00pm

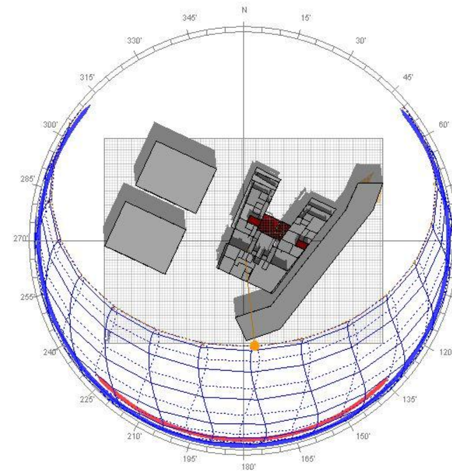
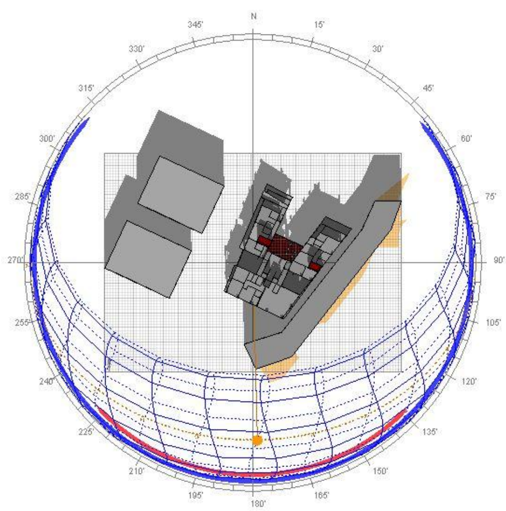
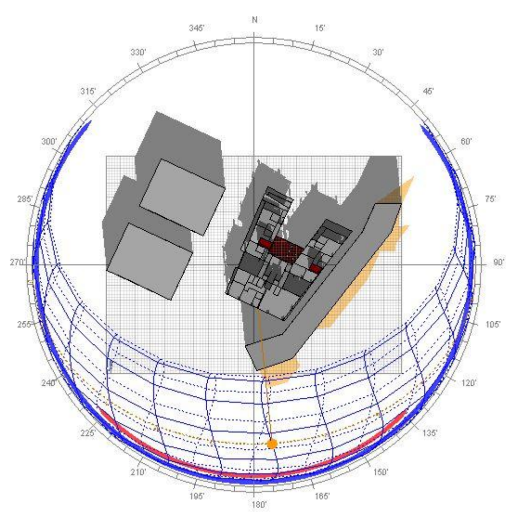


Figure 153 solstice at 12/ am

20th September winter equinox 12:00pm



20th March summer equinox 12:00pm

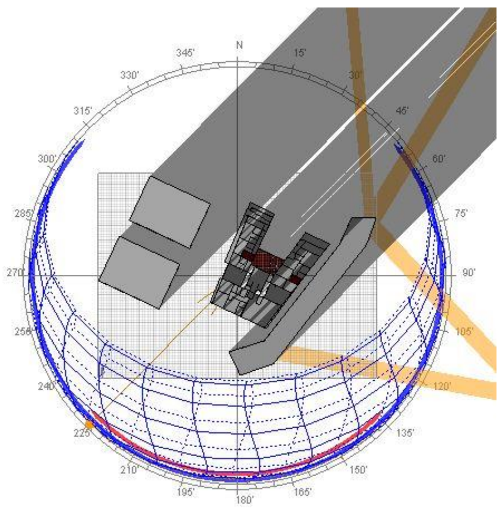


All the above figures shows the different shadow of analysis of the same building with different sun positions in winter solstice, summer solstice, September and March equinox respectively. The phenomenon has been explained above. The only difference is the time of the day. These shadow analysis are for noon i.e. 12:00 pm or at “Zenith”.

the shadows of this hour in June show the necessity of providing horizontal shading on south west façade and west façade which receive a wide range of solar radiations, though the number of sunny days and hot days are very few in Salford, the shading could provide adequate shadows for summer days.

4.3.3 Shadow at 16:00 pm in four different seasons

20th December winter solstice 16:00pm



20th June summer solstice 16:00 pm

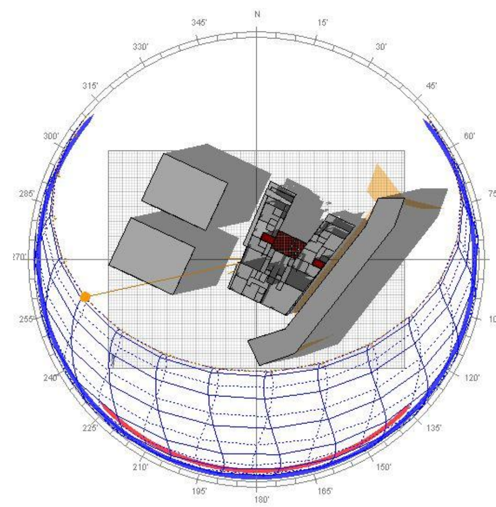
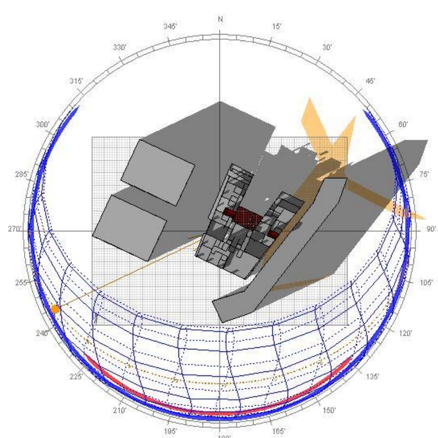


Figure 154 summer winter solstice 16 p.m

20th September winter equinox 16:00pm



20th March summer equinox 16:00 pm

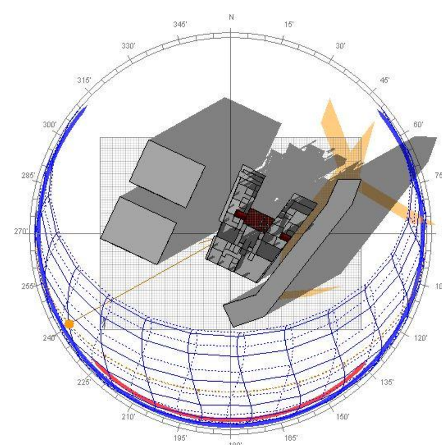


Figure 155 equinox 16 pm

The figures above shows the different shadow of analysis of the same building with different sun positions in winter solstice, summer solstice, September and March equinox respectively. The phenomenon has been explained above. The only difference is the time of the day. These shadow analysis are for evening 4:00 pm when sun is at lower position & penetrating the building from south south west to west side so we need to design shading in such a way so we could reduce the solar gain in summer. As it is seen in December shadows, a wide range of sun rays should be able to penetrate through the windows as the sun as quite inclined and has no obstacles on its way to our building.

Following a number of figures will show the shadow situation, from the Sun view in some of the critical hours of the day. This is in fact the view as if we are looking at the building from the true position of sun.

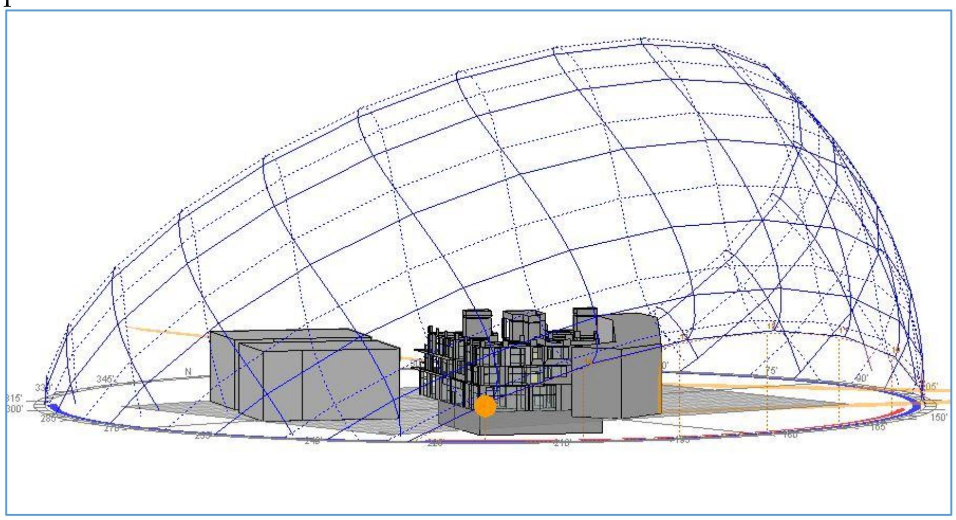
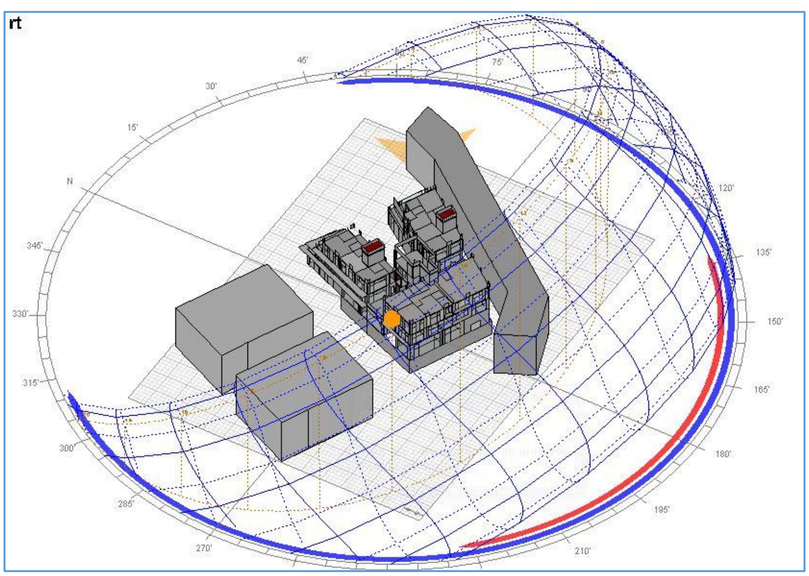
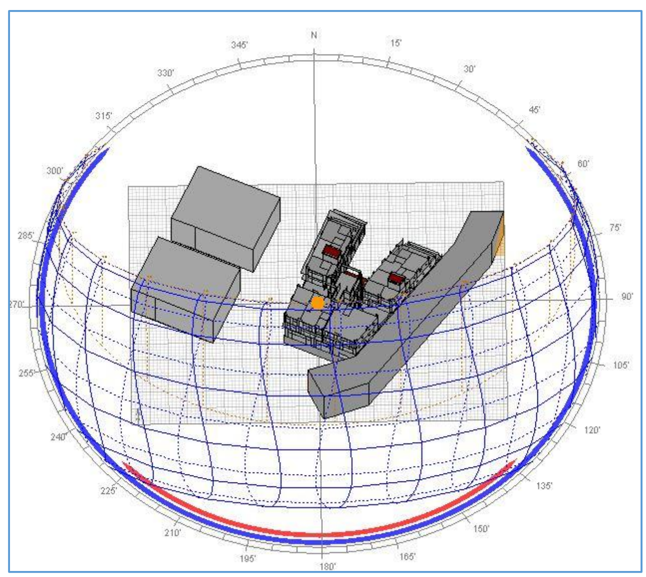


Figure 156 Above sun view Dec,16 pm , Below left: sun view Dec 16 pm Right: Sun view Dec, 12 :00

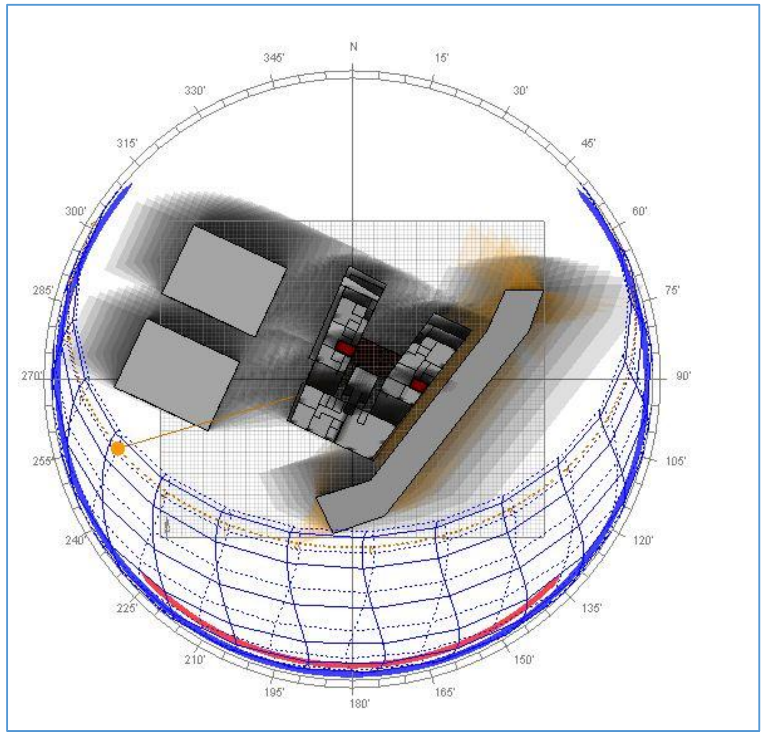




4.3.4 Shadow range

This analysis explains the shadow range of the building. We can observe that the shadow is the longest when it is due to winter solstice. We will have the shortest shadow in summer solstice because the sun is at the highest altitude. In the figure you may also see the effect of surrounding building on our project.

the two building on west have little effect on our building. In the following figures we can see the effect of our building shading system.



4.3.5 Effect of shading system

The following figures are exported from Revit based on our model. Here we have chosen a view from the south west angle, which shows the main lines of the shading system , which are the concrete slabs coming out of the building. We have studied the shadows the shading system provides in some important dates and times.

Figure 157 shading system effect . summer solstice 12 p.m

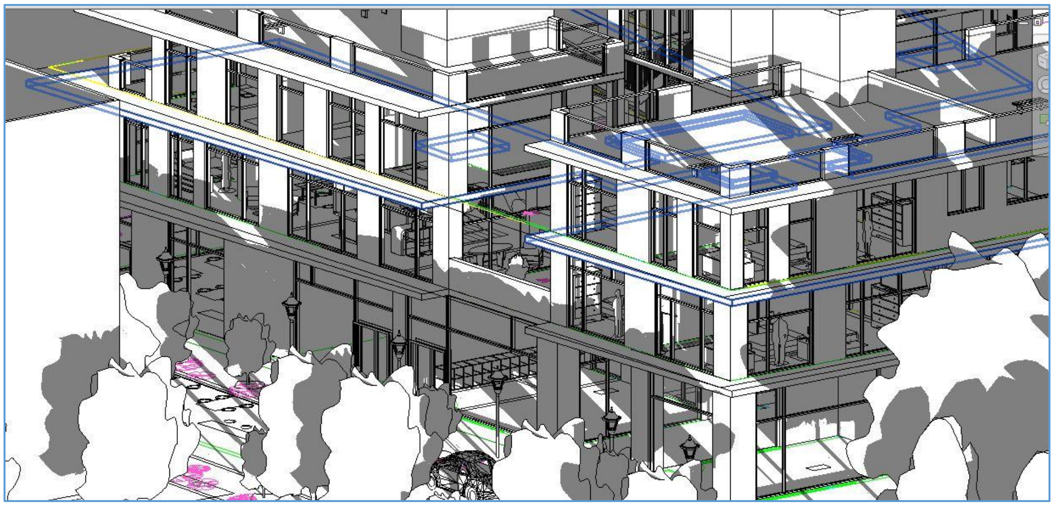


Figure 160 shading system effect,winter solstice 16 p.m

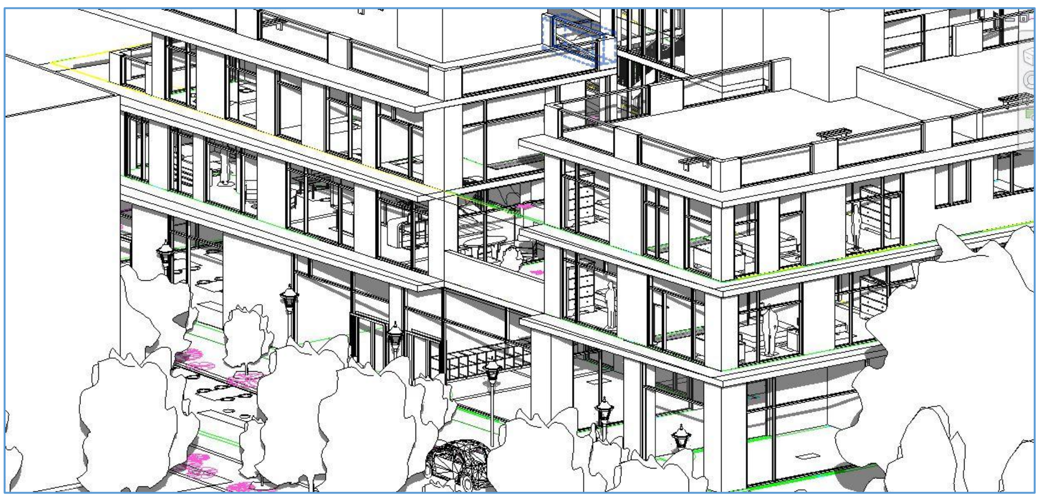


Figure 158 shading system effect, March 20th 16 pm

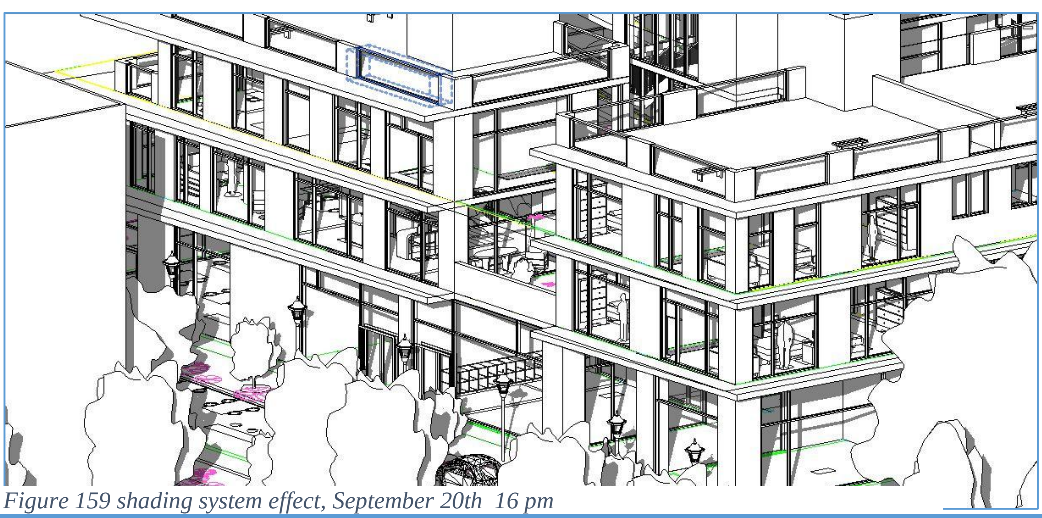


Figure 159 shading system effect, September 20th 16 pm

As it can be observed from the figures above, the shading edges are capable of covering almost all the façade in Summer solstice at noon time, when sun is at its highest position. In Winter solstice being December 21st , at 4 p.m. we can see that the horizontal shades let solar rays penetrate easily into the spaces.

As also seen and discussed before, in winter and summer equinox we are expecting almost the same results, as it is obvious in the figures. At 4 p.m. during these 2 days we see sun can penetrate in the spaces well, which brings us a maximized level of solar heat gains.

4.4. DAYLIGHT FACTOR CALCULATION

Daylight admitted into a building through `holes' in external fabric (windows, roof lights, etc.), which in adverse climates generally incorporate glass or an alternative transparent material to heat loss and/or inclement weather spaces. The amount of light received inside a building is usually only a small fraction of that required - because of modifications imposed by the size and position of openings - and will also constantly vary owing to the influences imposed on the `whole sky', illumination level by clouds, buildings and/or other reflecting planes. 11 The quality of space is greatly influenced by light coming in, and apart from the necessity for a certain amount of light for reading and other activities, light can have a great architectural rule, which can provide interesting games of light-shadow. For practical purposes, use is made of the daylight factor. This is a percentage ratio of the instantaneous illumination level at a reference point inside a room to that occurring simultaneously outside in an unobstructed position.[77]

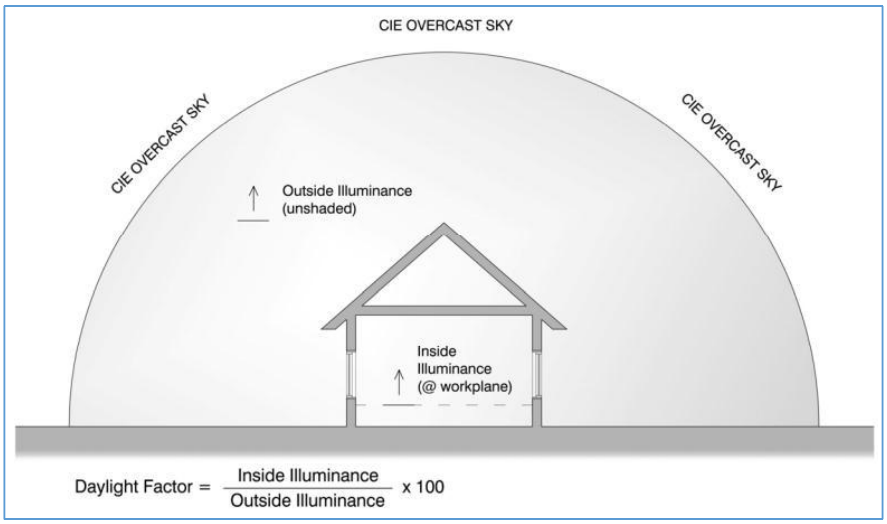


Figure 161 daylight factor calculation diagram

- The daylight factor (DF) is a metric used to quantify the amount of diffuse daylight in a space. (Diffuse daylight is light that has been scattered in the atmosphere before reaching the Earth's surface). It is usually measured at the height of the workplace (i.e. a desktop), under a standardized CIE overcast sky. It is defined as the ratio of the luminance of a point in a building and the illuminance at an unshaded outside point of a point in a building and the illuminance at an unshaded outside point facing upwards: DF = (Ein / Eext) × 100 Ein: Interior illuminance at a fixed point on the work plane. Eext: Exterior illuminance under an overcast sky.
- The 'mean daylight factor' of a room is the average daylight factor value of a grid of sensors at work plane height that extends across the room.

[77] http://home.wlv.ac.uk/~in6840/Daylightfactor.htm

- According p to the British Standards Institution, BS 8206 part 2 CIBSE a space with a mean daylight factor between 2% and 5% is considered well lit and requires little or no additional lighting during daytime. A space with a daylight factor of less than 2% appears dimly lit. Some examples of daylight factor requirements in different space types are listed below: [78]
Space Type Target
Office/Retail 2%
Classroom/Conference Room 3%

Circulation Area 1% Average DF	Appearance	Energy implications
<2%	*Room looks gloomy*	*Electric lighting needed most of the day.*
2% to 5%	*Predominantly daylight appearance, but supplementary artificial lighting is needed*	*Good balance between lighting and thermal aspects.*
> 6%	*Room appears strongly daylight*	*Daytime electric lighting rarely needed, but potential for thermal problems due to overheating in summer and heat losses in winter.*

What dimensional constraints does the target level impose?
Daylight penetration in a space varies linearly with window head height. The relationship factor varies depending on whether or not a shading device is used .
With a shading device: limiting depth: 2 . h windows head height
This limiting depth limiting depth allows for a space with an operable level of daylight allows for a space with an operable level of daylight throughout. Day light factor calculation (Split flux method):
In the method, the room is considered as a closed box into which light is admitted through an aperture that can be a window or a door. The various ways the light can enter the room is basically distinguished into three categories:
The Sky Component (SC), light coming from the visible part of the sky.
On BRS protractor SC is calculated only above 1m.
Final SC = SC * Correction Factor Externally reflected component (ERC):
The Externally reflected component (ERC), light reflected from opposing surfaces.

[78] A Design Sequence for Diffuse Daylighting 'DAYLIGHTING RULES OF THUMB' RULES OF THUMB' , Harvard Graduate School of Design Tiffany Otis | Christoph Reinhart

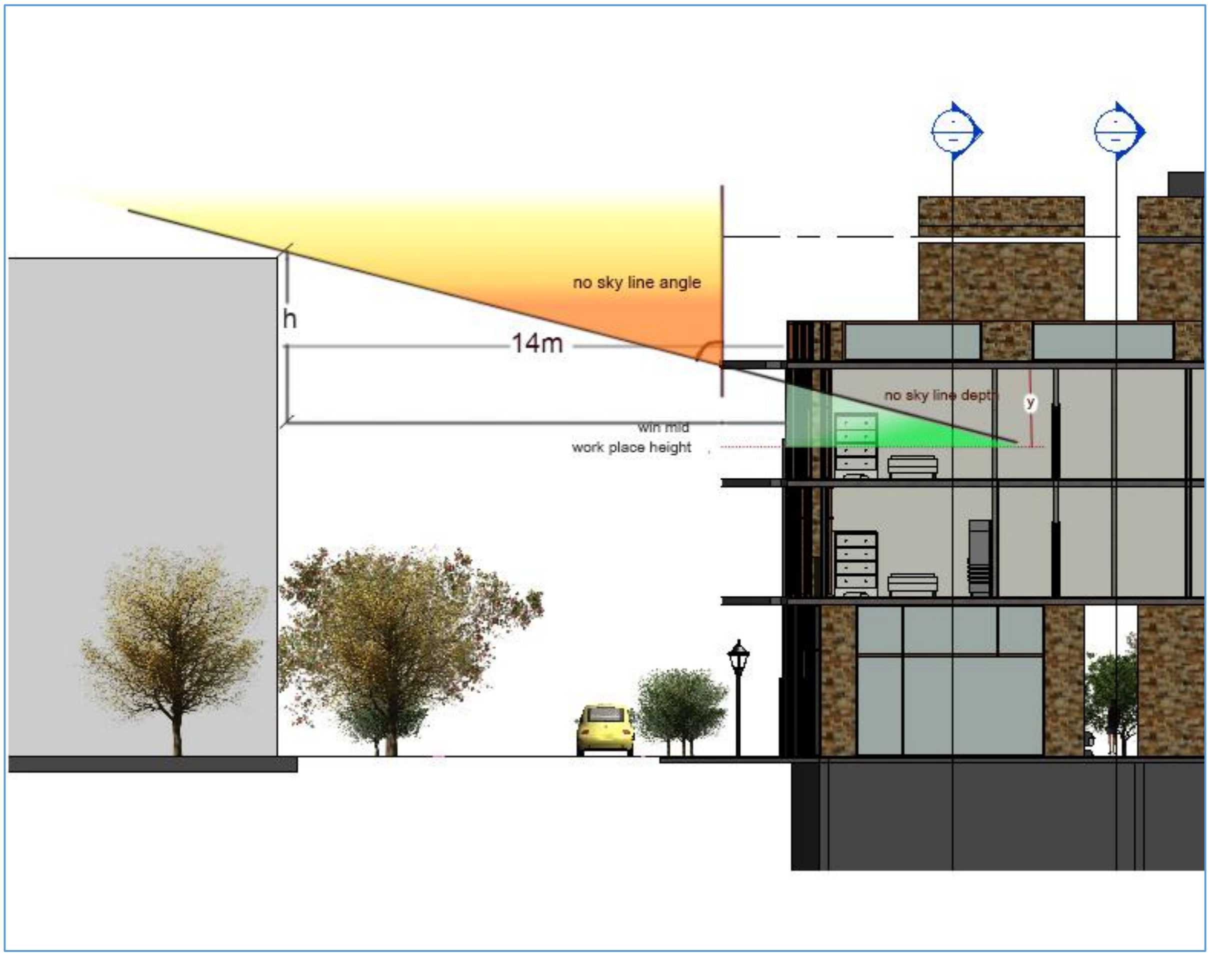


Figure 162 nearby building effect

Internally reflected component (IRC):
The Internally reflected component (IRC), light arriving from infinite possible paths.
A= Window area/ Total Surface area(Ceiling+ walls+ Floor area)
Average Reflectance = All Walls area/ Total surface area
B = Value from table against average reflectance value & 70% (As color of external walls is Light beige so they reflect more light).
C & D scales are used if there is any obstruction.
DF Equation: Finally, Daylight Factor
(DF) = SC + ERC + IRC.
With the use of the set of protractors developed by the building research station we are able to calculate the Sky Component (SC).
DF = (SC + ERC + IRC) x M x G x B
where, M: maintenance factor
G: glass factor
B: bars or framing factor

4.4.1 Daylight factor for unit number 1

We have exported data from our BIM model in form of gbXML into revit to have the geometry for daylight and other analysis. Thanks to the precision of this export-import procedure we achieved a model in Ecotect with correct positions and dimensions. We chose a height of 1 meter from ground to place our analysis grid, and in this unit it means it will be 5.5 meters above ground. It has opening on its four sides but the main space face south west and north west.

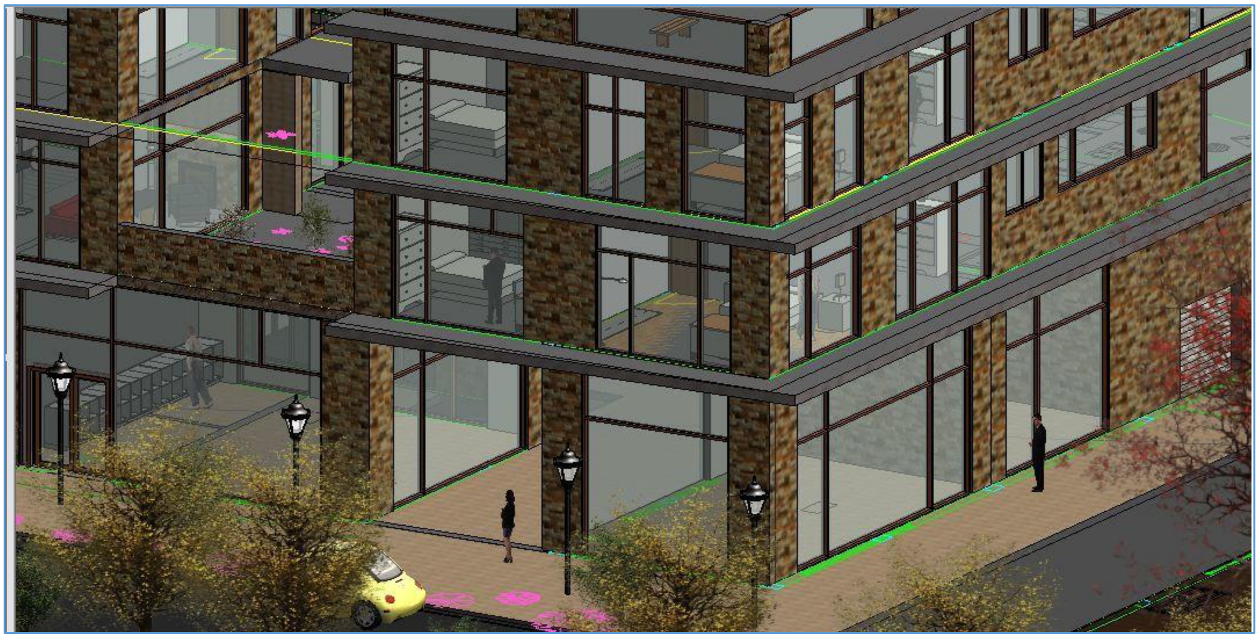


Figure 163 unit 1 - First Floor

we have considered the entrance and the spaces around it as the Service zone, which contains bathroom and locker room. Together with the Tv area these spaces require the minimum of lighting.

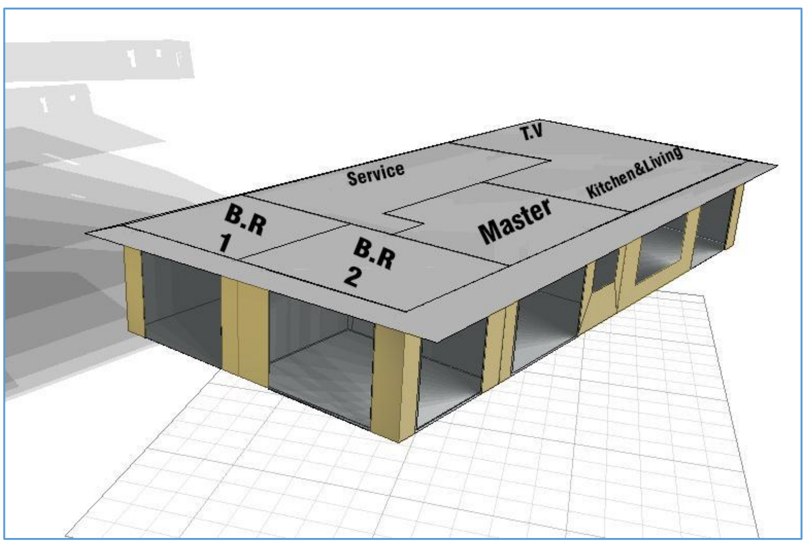


Figure 164 unit zones

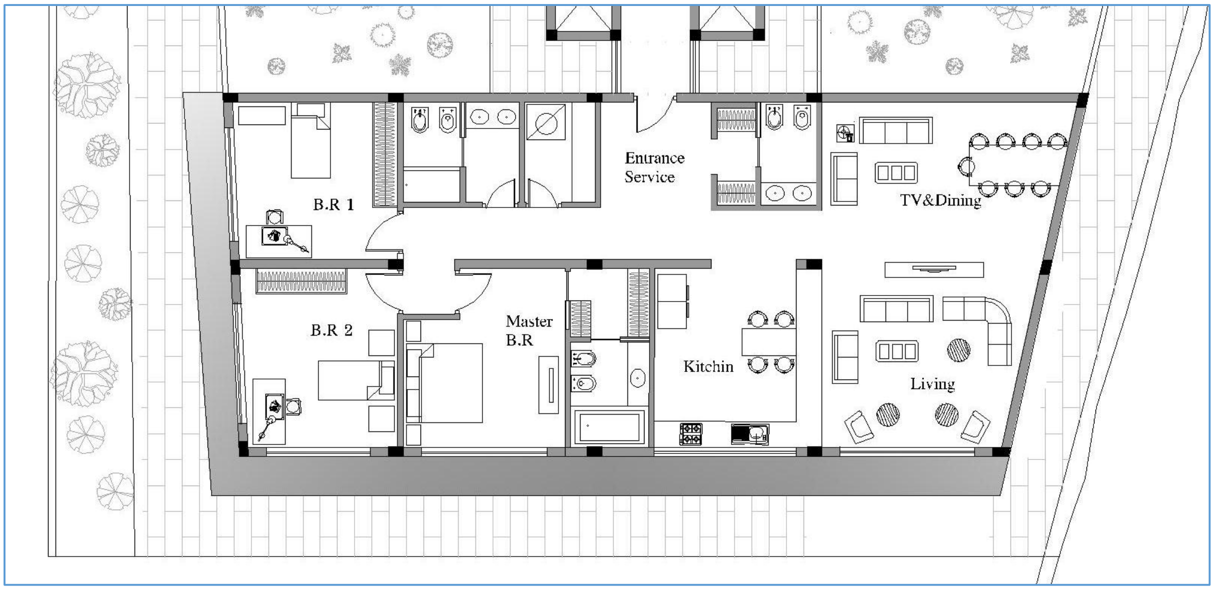


Figure 165 unit 1 plan

At 1 meter height from the floor level, the analysis of daylight have been performed with a range of minimum daylight of 1% to a max of 20% ,with an average daylight factor of 3.

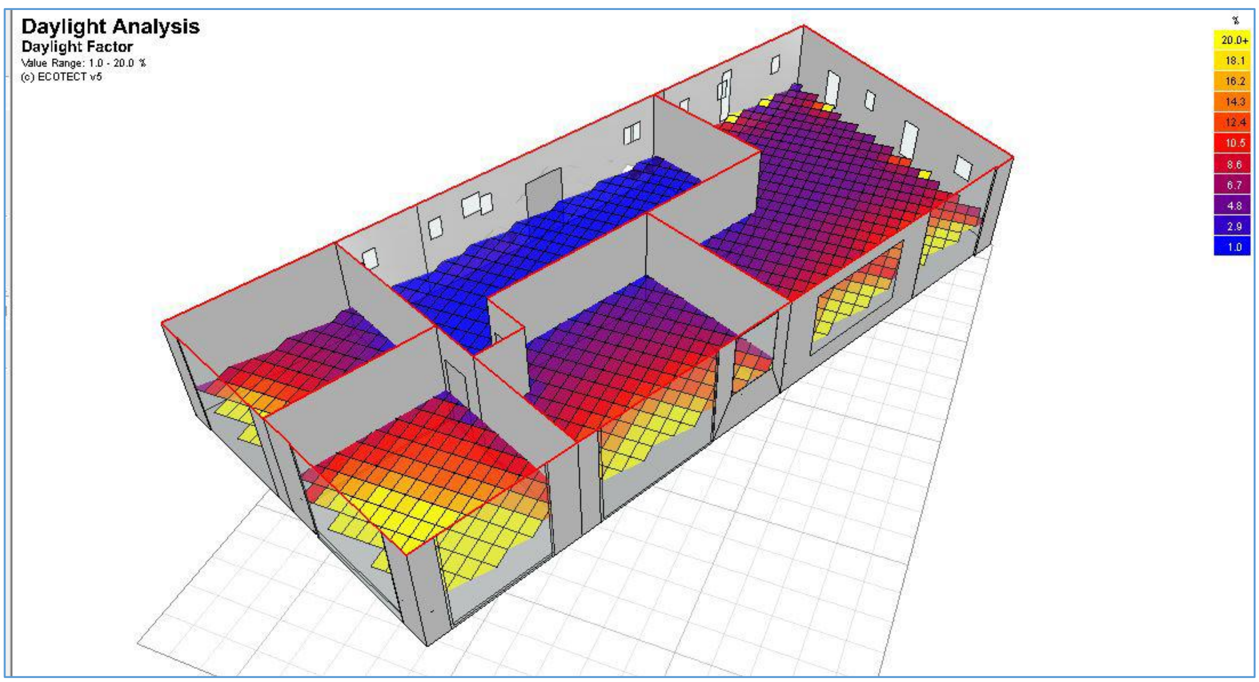


Figure 166 daylight analysis

As seen from the figure above, the main spaces being bedrooms, kitchen and living room receive much sun respect to service zoon and TV area, which indeed don't require more levels of daylight.

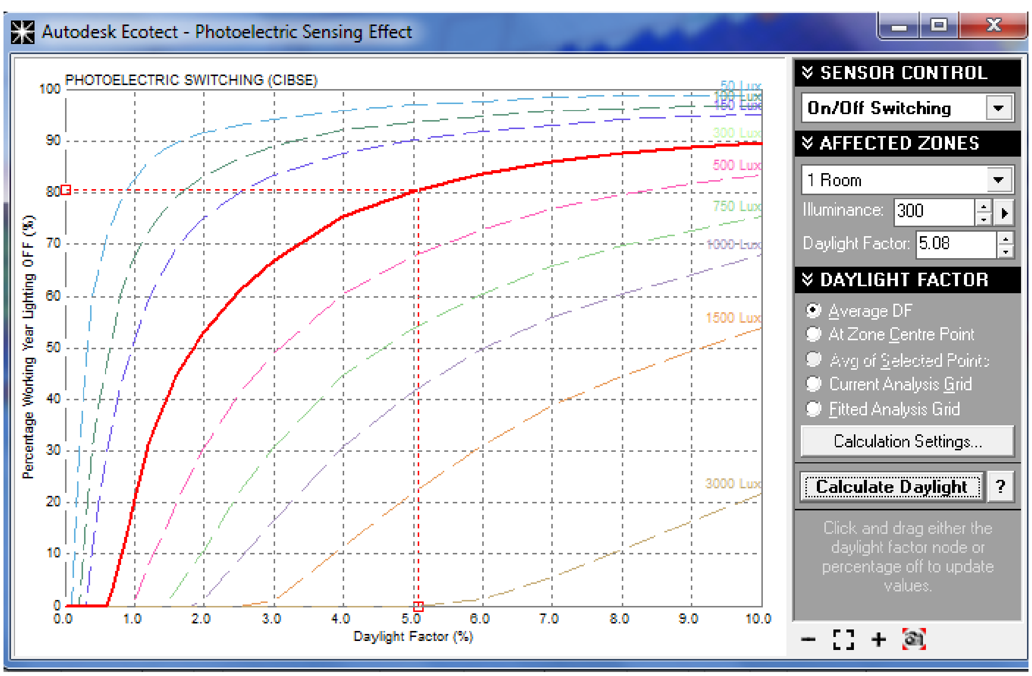
Standards for Daylight factor calculation:

Average DF	Appearance	Energy implications
<2%	*Room looks gloomy*	*Electric lighting needed most of the day.*
2% to 5%	*Predominantly daylight appearance, but supplementary artificial lighting is needed*	*Good balance between lighting and thermal aspects.*
> 6%	*Room appears strongly daylight*	*Daytime electric lighting rarely needed, but potential for thermal problems due to overheating in summer and heat losses in winter.*

The daylighting tool of Ecotect provides further analysis as well, such as Zone specific daylight analysis which is under the Photoelectric section of analysis. As seen in the Figure below, as an example a graph of photoelectric sensing effect is presented. At right side of the box we see the Average Daylight Factor for room 1 is 5.08. Comparing to the standard chart above, we see the average DF is in a very good range

Space Average D.F

Bed Room 1	5.08
Bed Room 2	8.80
Master B.R	5.00
Kitchen, Living	3.50
Service Zone	0.45



4.4.2 Daylight autonomy

As one the features of ecotect, it provides us with an analysis based on the grid, after having done the daylight analysis, which is called daylight autonomy. The program defines it as : '' The daylight factor is used to calculate the illuminance level at each analysis point at any time of the day, for any day of the year. Thus it is possible to determine how often the illuminance each point will be above a certain value. This is known as daylight autonomy and is given as the percentage of time throughout the year that each point will need no additional light to maintain the selected level. This equation is considered valid for mid-latitudes in the UK and Europe.

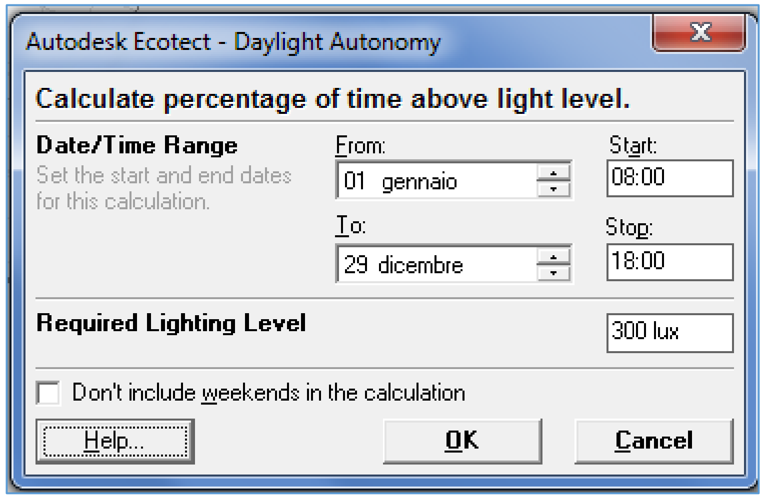


Figure 167 ecotect dialoge box

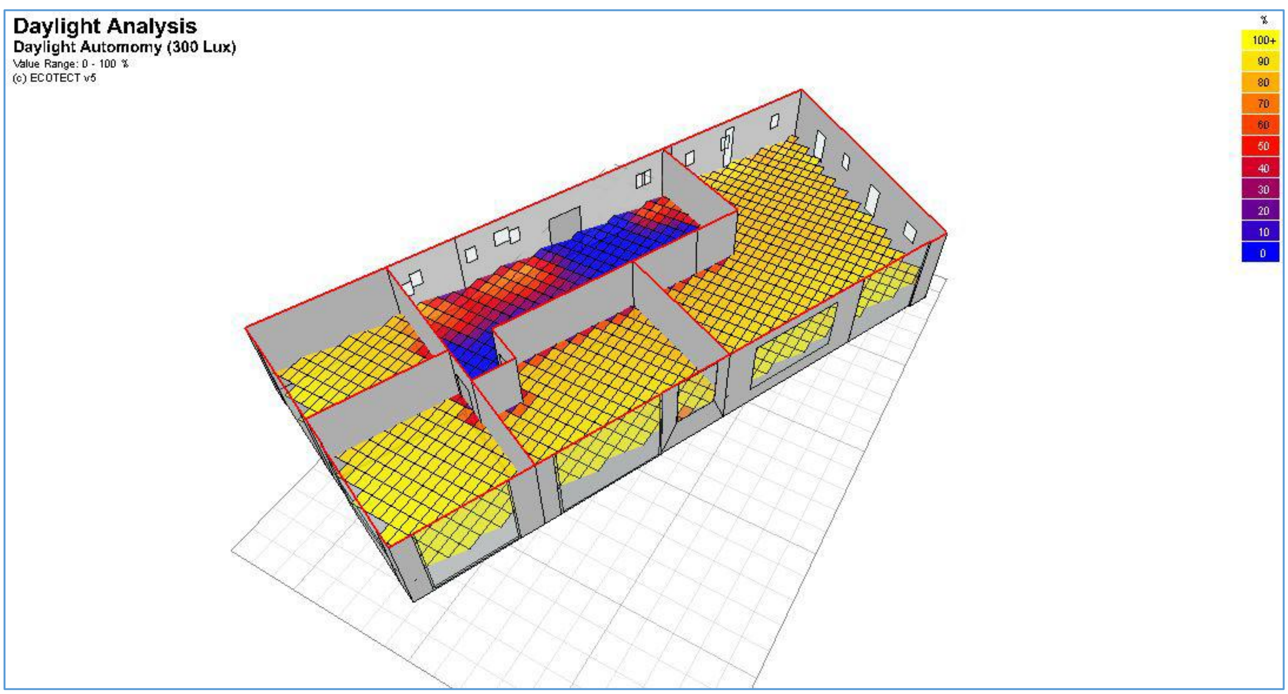


Figure 168 daylight autonomy analysis

4.5. Green building strategies

In this chapter we try to define and establish our strategies for an energy efficient, green and sustainable building. Up to this section we have seen the climate and site specific situation and analysis, and we have seen the effects of orientation and light on out building. So after having a look at European and UK specific strategies and efforts in the field, we try to design solutions for the issues and strategies for benefits.
Here we see some important titled extracted from a booklet explaining UK's *strategies for sustainable construction*, supported by some UK official organizations such as: Department for Environment, Food and Rural Affairs (Defra) , Department for Innovation, Universities & Skills (DIUS) , Office of Government Commerce (OGC) Centre for Expertise in Sustainable Procurement and some other officials. In its introduction we see: '' Government and industry share a vision of construction as a competitive sector which plays a central role in delivering sustainability and prosperity across the economy.
The Government has introduced a wide range of measures to promote competitiveness, most recently in the Enterprise Strategy, Enterprise: unlocking the UK's talent2 and the Innovation White Paper, Innovation Nation3. This Strategy is developed by Government and the industry to focus on sustainability in construction. '' the figure below summerises these strategies in a graphical way, which shall be supported by government and industries of UK . [79]

	Chapter Headings	Overarching Target
The 'Means'	Procurement	To achieve improved whole life value through the promotion of best practice construction procurement and supply side integration, by encouraging the adoption of the Construction Commitments in both the public and private sectors and throughout the supply chain.
	Design	The overall objective of good design is to ensure that buildings, infrastructure, public spaces and places are buildable, fit for purpose, resource efficient, sustainable, resilient, adaptable and attractive. Good design is synonymous with sustainable construction. Our aim is to achieve greater use of design quality assessment tools relevant to buildings, infrastructure, public spaces and places.
	Innovation	To enhance the industry's capacity to innovate and increase the sustainability of both the construction process and its resultant assets.
	People	An increase in organisations committing to a planned approach to training (e.g. Skills Pledges; training plans; Investors in People or other business support tools; Continuous Professional Development (CPD); life long learning). Reduce the incidence rate of fatal and major injury accidents by 10% year on year from 2000 levels.
	Better Regulation	A 25% reduction in the administrative burdens affecting the private and third sectors, a 30% reduction in those affecting the public sector by 2010.

79 Department for Business, Enterprise & Regulatory ReformConstruction Sector Unit, Copies of the Strategy are available at: www.tinyurl.com/yua68g

The 'Ends'	Climate Change Mitigation	Reducing total UK carbon dioxide (CO2) emissions by at least 60% on 1990 levels by 2050 and by at least 26% by 2020. Within this, Government has already set out its policy that new homes will be zero carbon from 2016, and an ambition that new schools, public sector non-domestic buildings and other non-domestic buildings will be zero carbon from 2016, 2018 and 2019 respectively.
	Climate Change Adaptation	To develop a robust approach to adaptation to climate change, shared across Government.
	Water	To assist with the Future Water vision to reduce per capita consumption of water in the home through cost effective measures, to an average of 130 litres per person per day by 2030, or possibly even 120 litres per person per day depending on new technological developments and innovation.
	Biodiversity	That the conservation and enhancement of biodiversity within and around construction sites is considered throughout all stages of a development.
	Waste	By 2012, a 50% reduction of construction, demolition and excavation waste to landfill compared to 2008.
	Materials	That the materials used in construction have the least environmental and social impact as is feasible both socially and economically.

Figure 169 Brief of UK Strategeis for Sustainable Construction

4.5.1 Uk examples

Eco-housing, or houses built in accordance with the principles of sustainable development, which use resourcesand technologies that capitalise on renewability, are a fast-developing industry in the UK. There have been a number of good examples done in UK as following:

-The Bed ZED Project, London:

The Bed ZED Project, or Beddington Zero Energy Development, is the UK's largest carbon-neutral ecocommunity in the UK. It was built in 2002 in Wallington, Surrey,Within the London Borough of Sutton, and comprises of 82 residential homes. The houses are equipped with key features, both technological and common sense - for example,designed in south facing terraces to maximise solar heat gain, that utilise renewable, and conservable, energy.

-Slateford Green Housing, Edinburgh:
A second public housing eco-project is the Slateford Green Estate, in Edinburgh.The project, consisting of 120 homes, was developed by a housing association together with the Scottish housing agency, in 2000, at a cost of £9.5 million. Some of the features in the houses include insulation from recycled newspapers, photovoltaics, a recyclable aluminium roof, and a breathing wall membrane, layered upon an engineered timber structure.

-The Findhorn Foundation Eco-Village:
On Scotland's north-east coast, near the town of Forres, is the Findhorn Foundation, an intentional community, based upon the values of spirituality and sustainable living. Part of its project is an eco-village, which consists of 45 ecologically-built buildings (so far, although the vision is much more).

They have developed a unique construction system that is energy efficient and environmentally sound. All the buildings features are ecological innovations. Some of the original buildings are reconstructed whiskey barrels, bought from nearby distilleries; and there are also later-built straw bale houses and earth ships, which use recycled car tyres.

4.5.2 Project Strategies:
In any construction we should seek the achieve the benefits of a sustainable work which could be Lower electric and utility costs, Environmentally effective use of building materials , Enhanced health and productivity and natural environment, Long-term economic returns and reduced environmental impact.
The main factors to have in mind are the results of analysis we have seen so far which makes us know the capacities of Greengate area, in terms of efficient energy use. Though our site was limited to choose orientatiob for the building, we tried to make most of the current situation. Following a chart a drawn which represents our strategies design for Salford project which in the following chapters we will further discuss each strategy.

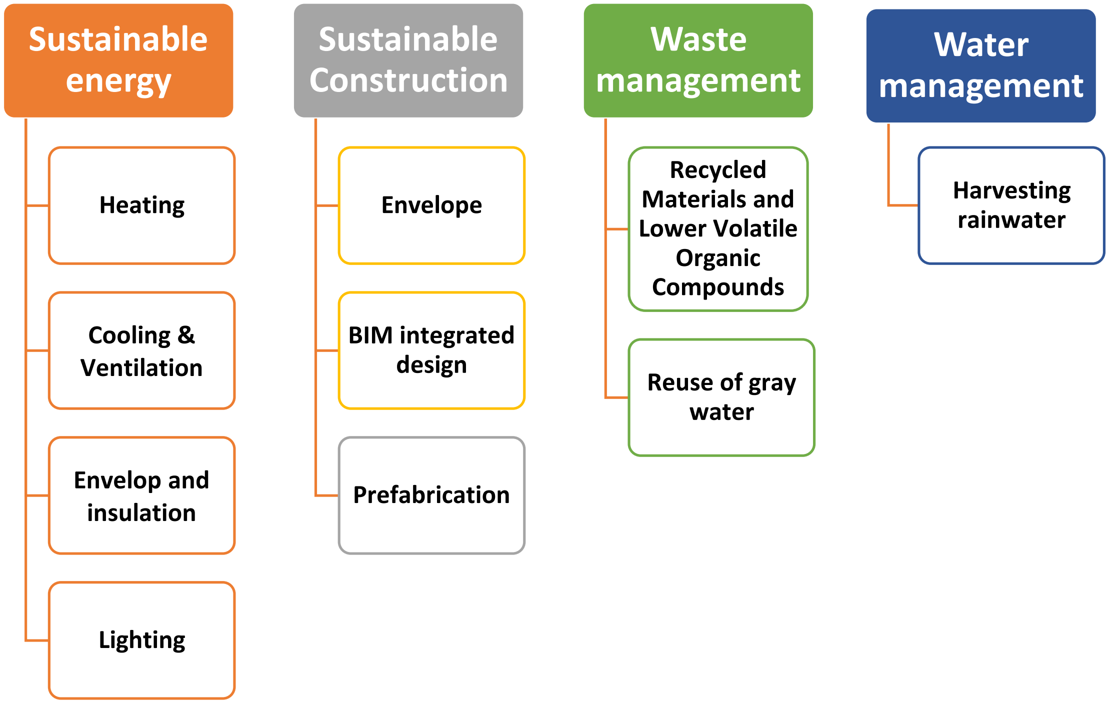


Figure 170 Sustainable Strategies Chart

4.6 Sustainable Energy

Sustainable energy is defined as energy which, in its production or consumption, has minimal negative impacts on human health and the healthy functioning of vital ecological systems.

in the following subchapters we will see a number of solutions and the ones more adopted for our building are further discussed.

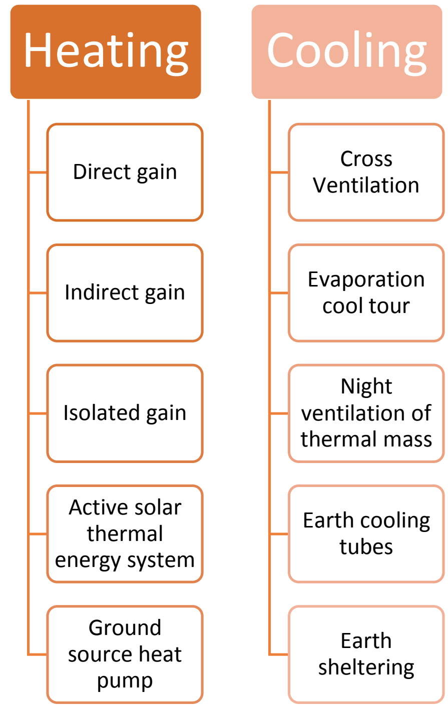


Figure 171 sustainable energy solutions

4.6.1 Heating

In this chapter we investigate the common methods and solutions for achieving an efficient heating and cooling systems. then we will adopt a number of them which are more suitable for our project according to geo climatic and architectural conditions of the building.

Such planning allows the designer to maximize the use of natural resources on the site. In temperate climates, open southern exposure will encourage passive solar heating;

Evergreens planted on the south side of a building ,where there is a small park or green area, will protect the building from winter winds, improving its energy efficiency.

4.6.2 Direct Gain:

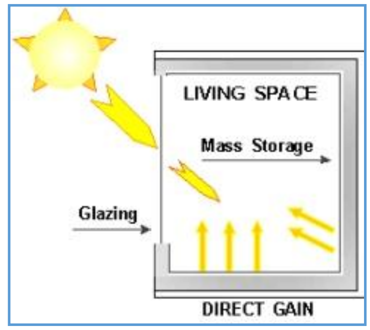


Figure 172 Direct Gain Function

To use the sun's heat without interference, and when the heat collection, storage and distribution all occur within the same space. The simplest and most efficient approach to passive solar heating is the concept of direct gain. The space itself is used as solar collector and must also contain storage capacity to absorb excess daytime heat gain for later release at night or on overcast dates. [80]
As we have large surfaces of concrete slabs in the floor, which can have good thermal storing capacities, and large area of fenestrations on our main façade, which welcome the entrance of sun rays, makes this as a suitable strategy to adopt for our project.

4.6.3 Insolation and solar exposure:

The have a better idea of this possible gains, we performed the Solar access analysis in ecotect for the period of winter, Insolation refers to Incident Solar Radiation and represents the amount of radiation incident on a point or surface over a specified period. First overshadowing masks are generated at each point due to surrounding buildings and objects, then hourly diffuse and direct radiation data is read directly from the climate data over a user-set period.

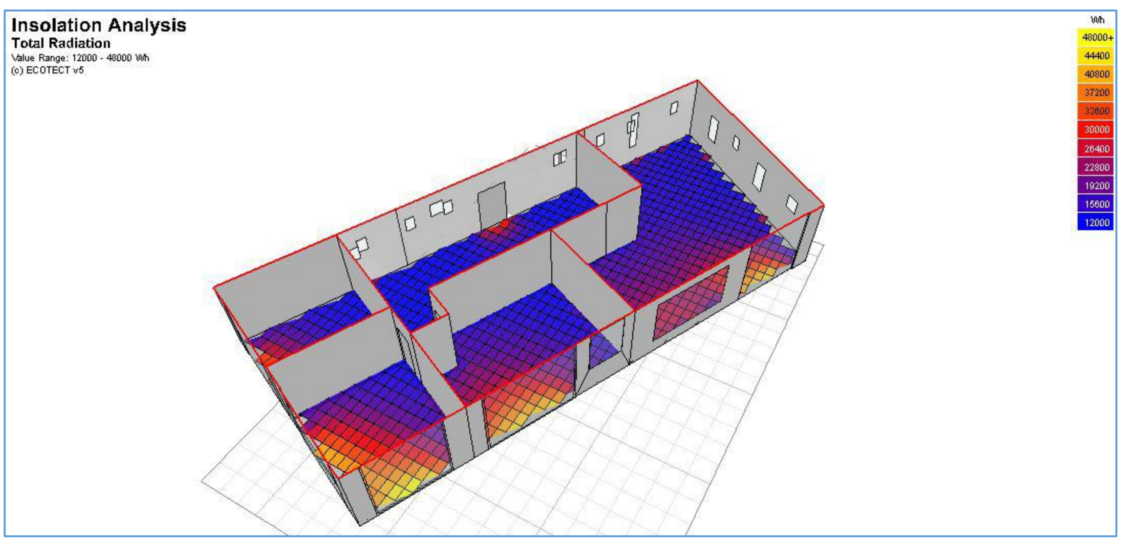


Figure 173 Total Radiation, Value 12000-48000 Wh

80 The Building Environment: Active and Passive Control Systems- By Vaughn Bradshaw – page .239

We can also do another analysis in ecotect which gives us information aobut the solar exposure. Following we will see the chart generated by Ecotect dispaying the amount of solar exposure on a monthly basis.

8

TOTAL MONTHLY SOLAR EXPOSURE
Manchester, England - UK
Objects: 0 (Exposed Area: 0.000 m2)

	AVAIL.	AVG	REFLECT	INCIDENT		ABSORBED		TRANSMITTED	
MONTH	Wh/m2	SHADE	Wh/m2	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh	Wh/m2	TOT.Wh
Jan	20478	100%	0	3217	3217	0	0	3217	3217
Feb	36384	96%	0	4823	4823	0	0	4823	4823
Mar	74335	95%	0	10710	10710	0	0	10710	10710
Apr	98429	100%	0	14001	14001	0	0	14001	14001
May	137337	100%	0	16165	16165	0	0	16165	16165
Jun	175828	100%	0	18278	18278	0	0	18278	18278
Jul	142031	100%	0	18100	18100	0	0	18100	18100
Aug	106167	100%	0	15094	15094	0	0	15094	15094
Sep	78592	100%	0	10468	10468	0	0	10468	10468
Oct	47564	100%	0	6560	6560	0	0	6560	6560
Nov	16831	93%	0	2682	2682	0	0	2682	2682
Dec	11780	88%	0	1959	1959	0	0	1959	1959
TOTALS	945756		0	122057	122057	0	0	122057	122057

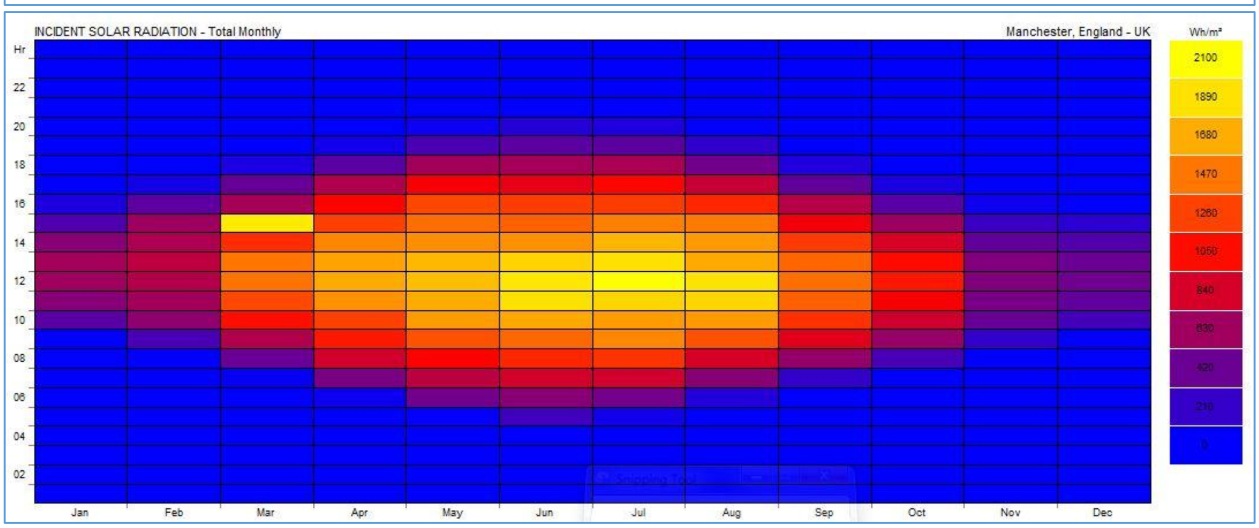


Figure 174 incident solar radiation

As seen in the above figure, during winter months the solar gains are more limited and can be around 420 to 1050 W/m² which of course is not very considerable and heating application are necessary during cold days of the years.

4.6.4 Indirect Gain

This system works with mass storage. The mass stores direct sunlight and then radiates the heat by convection into the desired spaces. As we did not have this possibility following out architectural design, this is not an option adoptable for our project. Also the application of a thermal wall was not possible through the project and this was completely away to fit into the building.

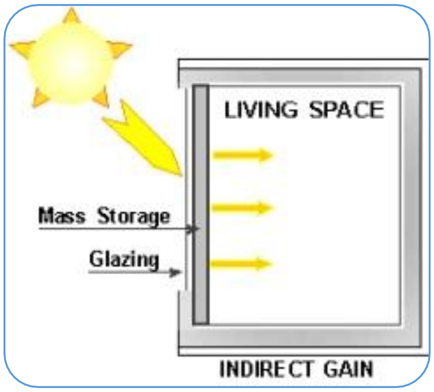


Figure 175 Indirect Sun Gain Function

4.6.5 Isolated Gain

Isolated gain system is a passive heating system that collects and stores energy from the sun in a building elements thermally separated from the occupied spaces of the building. The heat from the sunlight is then moved to the rest of the house by means of conduction through the separating wall at the rear of the room, or by vents that permit air between the room and living space to be exchanged.

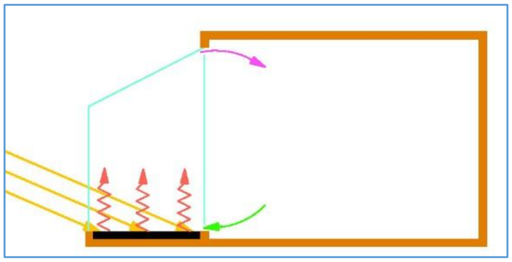


Figure 176 Isolated Gain Function

Sun rooms have some advantages as an isolated gain system in that it can also provide additional usable space to the house and plants can be grown in it quite effectively.
Also in this cas we could not adopt the system according to our architectural design, thought according to the space we have between to concrete slabs of the floors, eventually it can be an option to be adopted in future by the owners of the units.

4.6.7 Active solar thermal energy system:

Active solar thermal systems use solar collectors to collect the sun’s energy to heat water, another fluid, or air. The heart of a solar collector is an absorber that converts the sun’s energy into heat. The heat is then transferred by circulating water, antifreeze, or sometimes air to another location for immediate use or storage for later use.

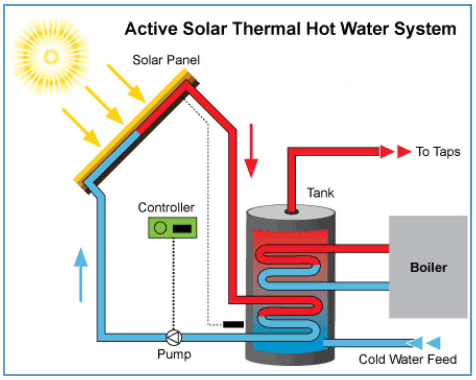


Figure 177 solar active hot water

Applications for active solar thermal energy:
-providing hot water, space heating, preheating air in both residential and commercial buildings ,heating swimming pools.

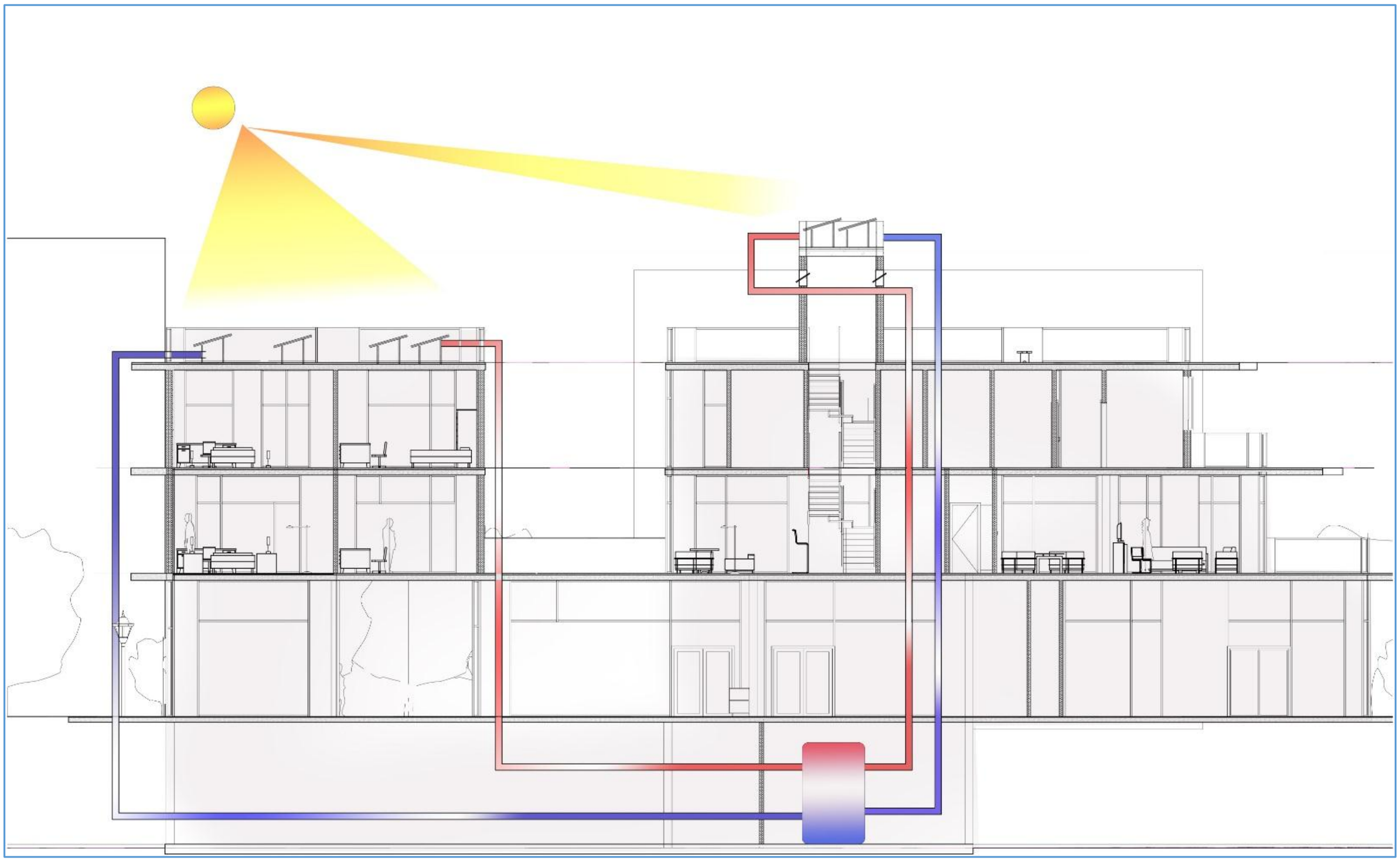


Figure 178 solar water heating system

As our building has a large roof top, we can place some solar panels on it which can be seen in the figure above, which can be uses for providing water heating. As seen in the analysis before, Salford does not have long hours of sunny days and just a solar based system could not respond to all its heating needs. Therefore the use of a mixed-mode system is suggested.

4.6.8 Ground Source heat pump

Geothermal energy is heat stored within the Earth. This heat originates from two sources; Radioactive decay in the Earth's crust (~40mW/m2) The Earth's core (~10mW/m2 at the Earth's surface) Heat filters through the mantle to the Earth's crust in areas of geological activity.[81] Ground heat pump is a central heating and/or cooling system that pumps heat to or from the ground. It uses the earth as a heat source (in the winter) or a heat sink (in the summer).

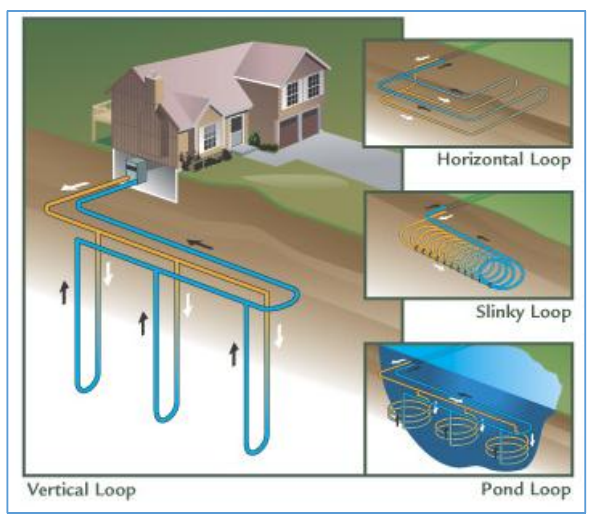


Figure 179 common Ground Source heat systems

[81] Sustainable Energy – without the hot air. David MacKay

It is a renewable form of energy with no fuel costs involved. Geothermal plants are efficient (after a suitable site has been located and a plant constructed), zero pollution is produced with virtually zero greenhouse gas emissions. Plants typically use less land area than conventional power plants and have less visual impact on the environment. It has been estimated that deep geothermal technology may supply 1 to 5 GW of **UK** base load renewable electricity by 2030 .[82]
Where can we utilise Geothermal energy?
Geothermal energy can be harnessed anywhere near the Earth's surface which is in close proximity to magma or volcanic activity. Iceland is a leading example where 90% of the country's houses are heated with geothermal energy. Within the UK, Southampton has a geothermal well which is more than 1 mile deep, reaching water heated to 760C. It produces 18% of the heating mix into the City's district heating scheme, supplies thousands of houses and saves 12,000 tons of CO2 emissions every year. In 2010 a commercial-scale (10 MW electricity, 55 MW renewable heat) geothermal power plant near Redruth was granted planning permission by Cornwall council .The Eden project (Cornwall) has been granted planning permission to build a hot rock geothermal plant (4 MW electricity generation for the site with a surplus going to National Grid to supply ~5,000 houses)[83].
In our Salford project, as we are near the Irwell River also, maybe it is an advantage for using such a system. As mentioned above, if we go down for a 1 mile depth, we may have an efficient system. The figure below shows the implementation of the system for our building. As under the court yard of our building we had enough space, the pipes are place in that area, in vicinity of the river, and use a Vertical Loop system.

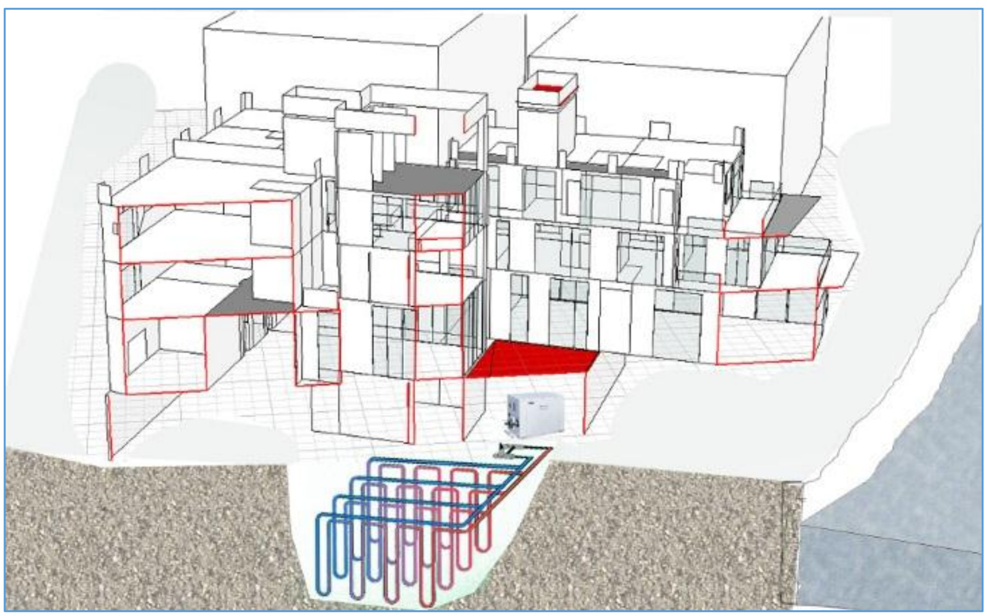


Figure 180 Vertical loop system

[82] DECC http://www.decc.gov.uk
[83] http://www.guardian.co.uk/environment/2009/jun/01/eden-project-geothermal-energy

4.6.9 Under Floor heating system:

Apart from the more efficient and sustainable system mentioned above, we have designed as well a mechanical heating system to guarantee the comfort level in cold days of the year. The system is Water circulates through plastic pipes that are arranged in loops that cover the whole of the floor. Heat radiates upwards from the pipes

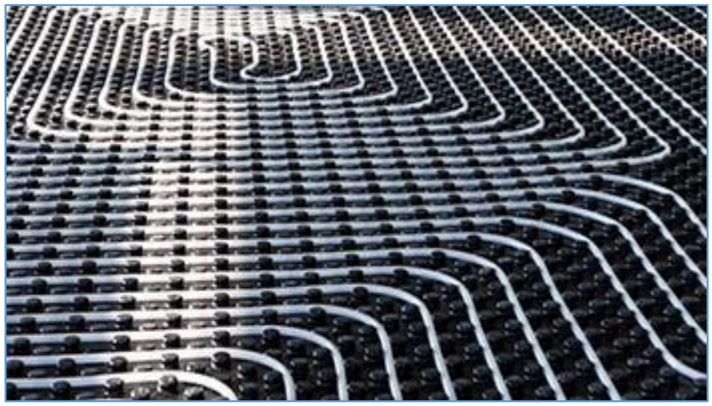


Figure 181 underfloor heating pipes

Reduced energy costs - Underfloor heating is a highly efficient way to heat a room. This is especially true when combined with renewable micro-heat technology such as air source or ground heat pumps as the water does not have to get as hot as the water required for your radiators. If you have a gas boiler it will be operating at lower temperature and so going through fewer firing cycles.

The whole floor is omitting heat that rises steadily up to the ceiling. So unlike a radiator the heat is evenly distributed around the room without all of the "cold spots." Also radiators result in warm air traveling up walls and being stored at ceiling height resulting in cold floors, heat loss through windows and dust circulation. In addition as the room heat is greatest around the radiator, you have to plan your room including furniture around that radiator.

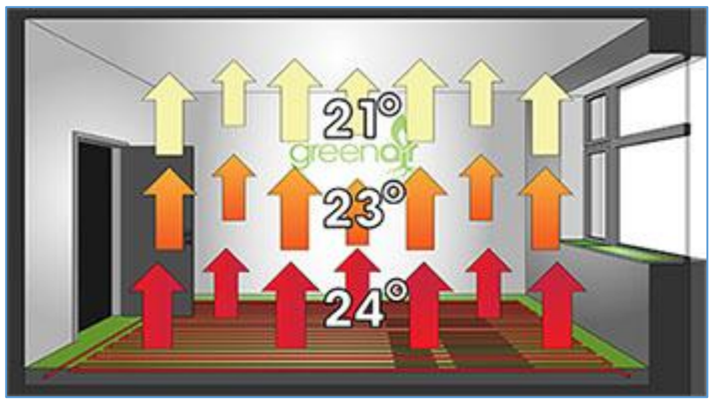


Figure 182 heat distribution with pipes

Lower running temperature so that you can heat your room to the same standards or higher than a radiator system.

Uniform heating throughout the room
Can be fitted into a floor depth as little as 20mm.
Also in architectural sense we will save some space and higher level of comfort are achieved through a combination of all systems implanted in our building.

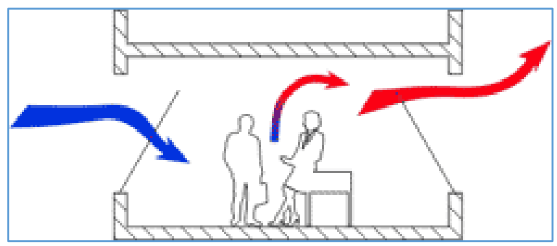
Figure 183 heat distribution by radiator

4.6.10 Cooling

As we had seen in the geoclimatic site specific analysis before, cooling loads in our project is not ascritical as heating and in fact in a few days of the year we may have temperatures to lead us out of comfort zone.Here we see a number of passive strategies of cooling and we will explain the ones adoptable for our project.

4.6.11 Cross ventilation:

Cross ventilation is obtained by having windows in both sides of the room, causing airflow across the space. In all of our units we have such a situation. As all our four units have openings towards four directions, a cross ventilation always happens in all the units.



In the figure below we can see the position of our building and its relation with the winds and Manchester, Salford areas. As discussed before, most of the winds with more speed and frequently blow from south towards north and the coldest one are eastern winds.

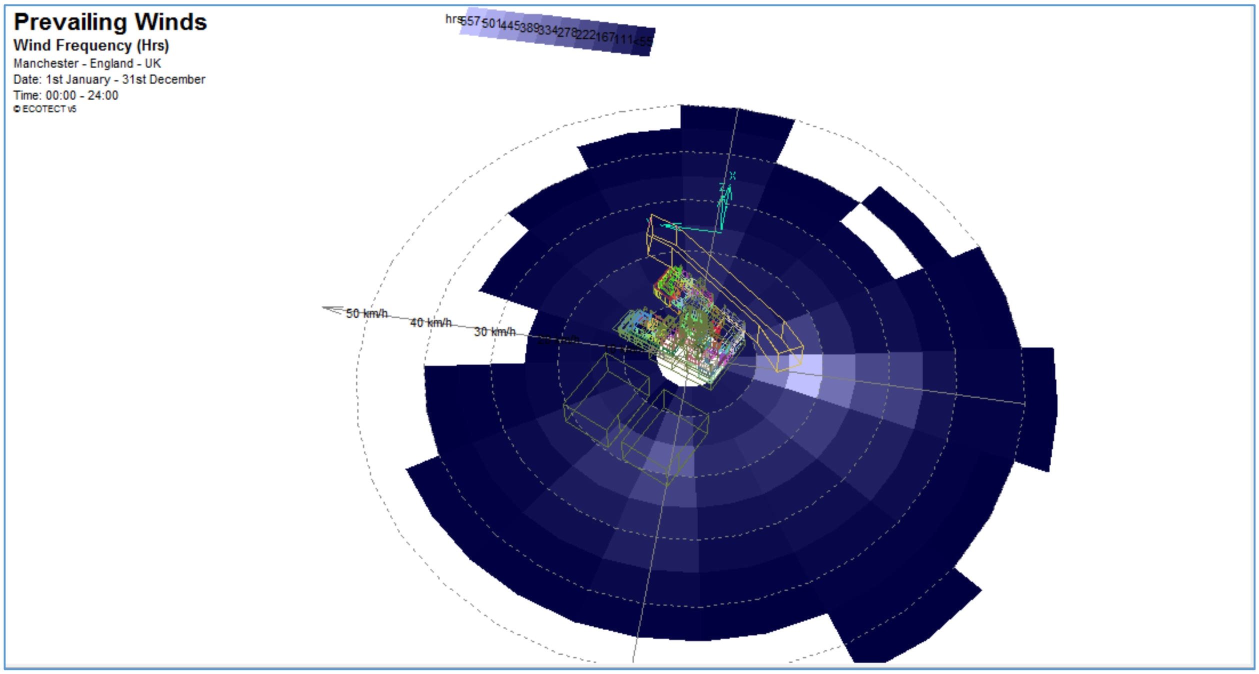


Figure 184 wind analysis on project site

There we try to use the benefits of a passive ventilation strategy. Our duplex flat have a tower that can act like the exhaust mechanism of a chimney and help ventilate easier. In the following figure we can see the schematic movement of hot and cold air and the passive strategy for ventilation throughout the apartments.

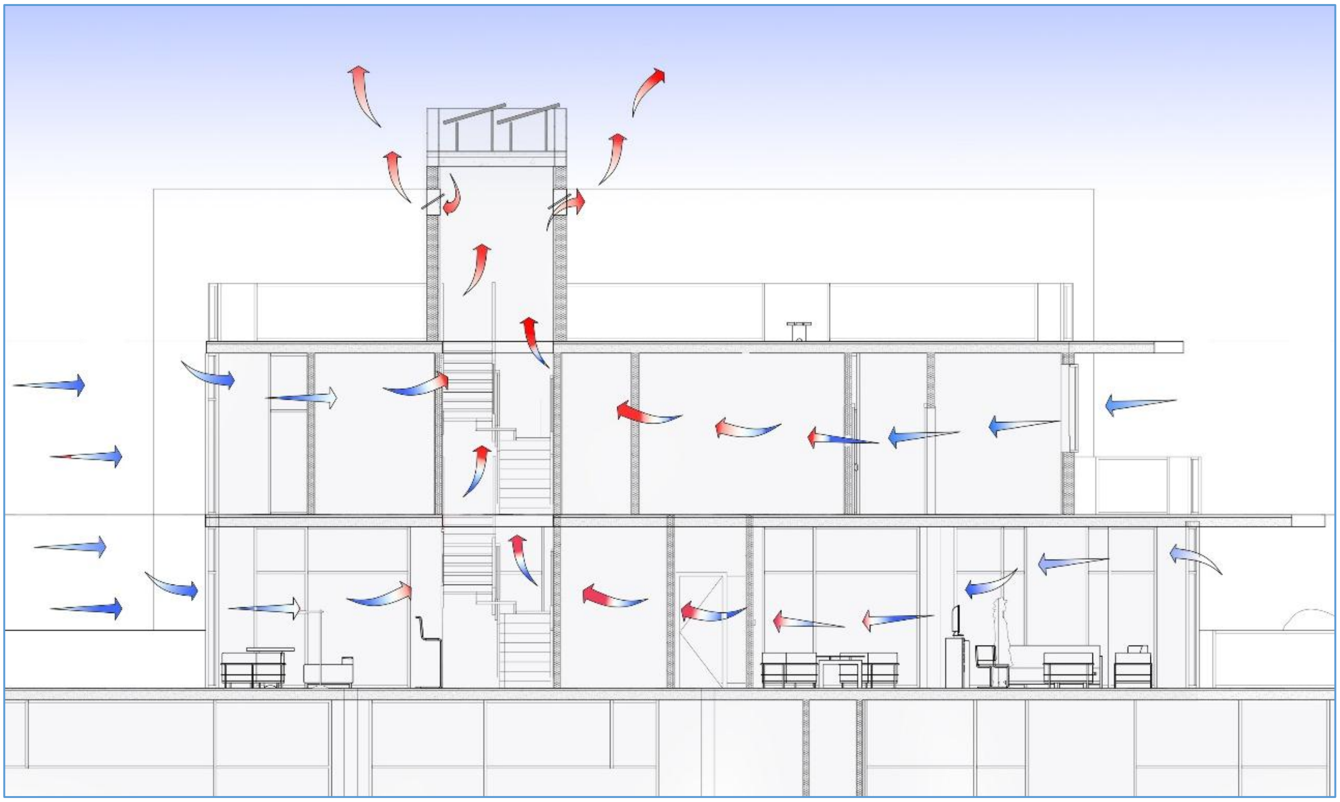


Figure 185 Natural Air Ventilation

As mentioned in previous chapters and shown above,, in North-East axis we have more wind frequency, especially from south to north direction. The large windows which are placed on all side of facades of each units, are divided into smaller segments which can be configurator in different modes of opening. This gives the users of the unit the flexibility in this function.
As seen in the sectional figure above, the chimney like structure which is vertically expanded in the unit, where the stair case takes us from first floor to roof top.
The other duplex unit can enjoy the natural ventilation via the same function. Instead unit 1 and 2 which are single floor apartments, do not have such a structure but still have large opening with adjustable smaller parts, and they have the largest fenestrations facing the strong wind axis.

4.6.12 Mechanical Ventilation

A network of air canals are extended through out the main spaces of the building, which are hidden under the false ceiling, as seen in the detail below. In the extends of lift well a mechanical space been considered to provide for access the mechanical pipes and air duct.

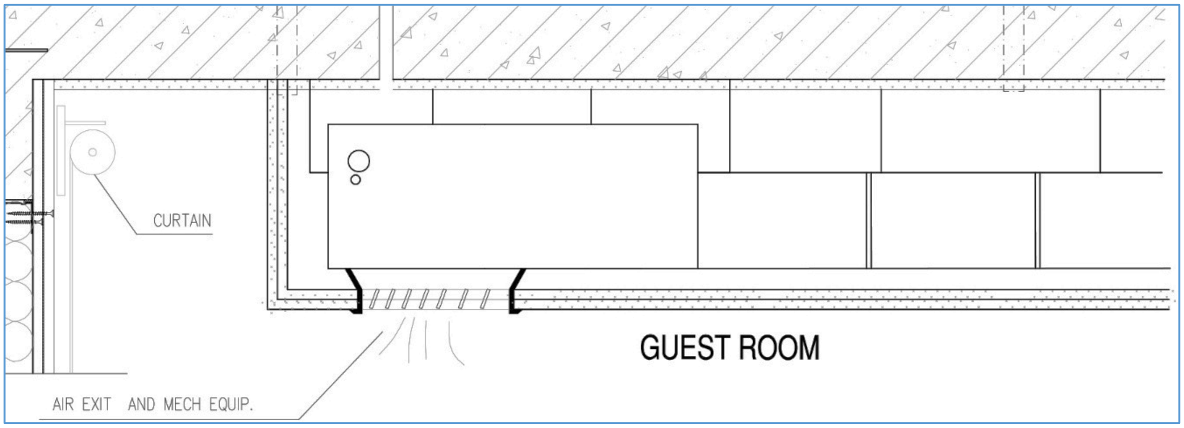
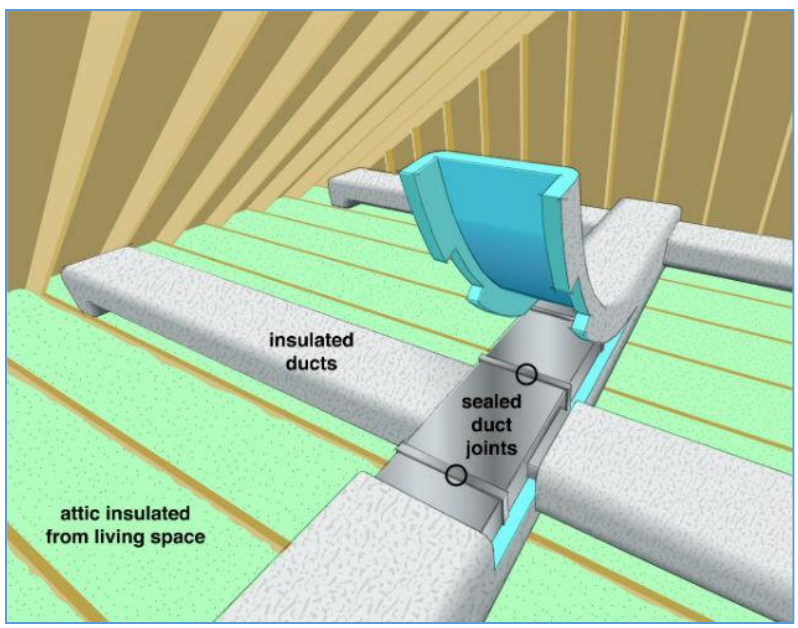


Figure 186 detail of air canals

Air duct insulation and hear recovery: A duct system that is properly sealed and insulated can make your home more comfortable, energy efficient, and safer. Making improvements to your duct system can: Improve Comfort Sealing and insulating ducts can help with common comfort problems, such as rooms that are too hot in the summer or too cold in the winter .

The energy saving by sealing the air ducts, also results in less consumption of energy and can be an important part of our green strategy.

In case of problem for pipe heating system, the air ducts can also bring in the heated air and it is important to have a Heat Recovery Ventilator is a complete whole house ventilation system that incorporates a supply motor and an exhaust motor in one unit. It is designed to bring a continuous supply of fresh air into the home while exhausting an equal amount of contaminated air. HRVs use what is known as a "sensible" heat recovery core.



4.6.13 Evaporation cool tower

Cool towers use gravity to move cool air without any fans, although fans may be used to reduce the size of the towers. The most common cool towers do this by having a wet pad medium in the top of the tower. Since cool air is heavier than warm air, it will fall, creating its own airflow. Wind is not required, but will improve the airflow in a cool tower .

Similar sustainable methods of such system can be tracked down in traditional architecture of desert area. Some great examples, both in sense of architectural and cooling function are found in Yazd city, Iran, as well as many different regions around.

As seen before, the chimney like structure in the duplex unit, could provide us such a possibility. Though cooling are required in a few days of the year and it seems not very necessary to adopt also this system for our project.

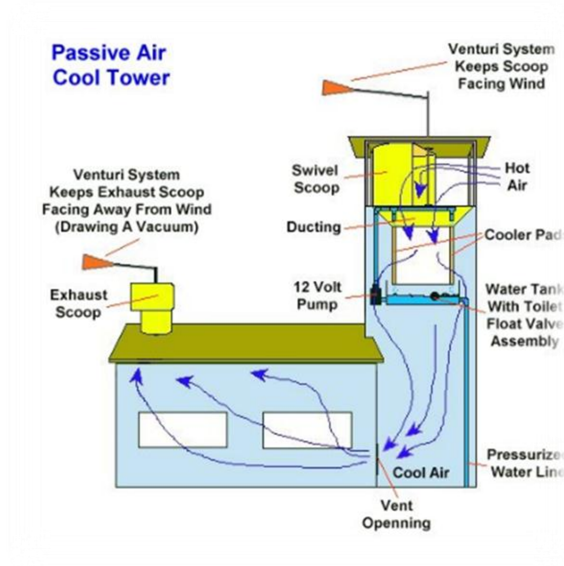


Figure 187 cool tower function

4.6.14 Night ventilations of thermal mass

Thermal mass can be used in conjunction with night ventilation of a building to provide passive cooling. Outside air is circulated through the building where it comes into contact with the surfaces and cools the building fabric.

Night ventilation is most effective in moderate climates such as the UK where the diurnal swing is sufficient that ambient temperatures at night fall below normal daytime internal comfort temperatures.

It is suitable for buildings with periodic daily loads such as offices. The use of thermal mass in conjunction with night ventilation can be used to minimize / eliminate the need for mechanical cooling. In the absence of mechanical cooling, comfort conditions can be maintained in applications with low to moderate cooling loads

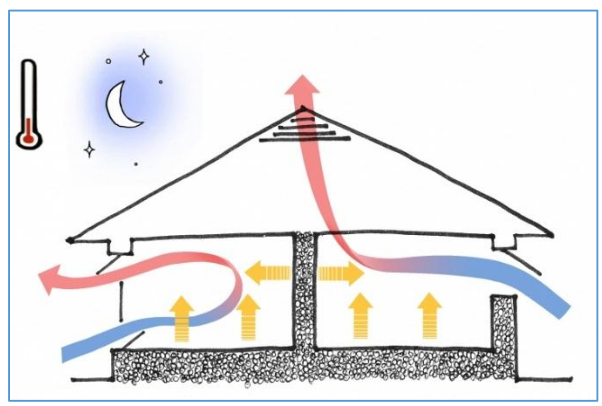


Figure 188 night ventilation

The cooling that is stored in the building fabric is then available to offset heat gains the following day and keep temperatures within comfort limits.

As we have large areas of concrete slabs and they have thermal mass capacities, and Salford is has a moderate climate, this method can help greatly to reduce the heat which is carried out of the building by ventilation.

4.6.15 Earth Cooling Tubes:

Earth cooling tubes present an alternative for controlling temperature within residential and office buildings as well as greenhouses and other structures requiring temperature regulation. These tubes run underground and alter air's cooling or heating temperature before it is allowed into a home or office. En route, the air releases its heat to the surrounding soil so it becomes cool air when it reaches its target structure. If the soil surrounding the tubes is warmer than the air within, the air acquires heat so it becomes warm air when it reaches its target. Along with earth tubes for warming such a system could be integrated to help reduce cooling loads. Again, considering the climate of Salford the implementation of such a sytem could be optional.

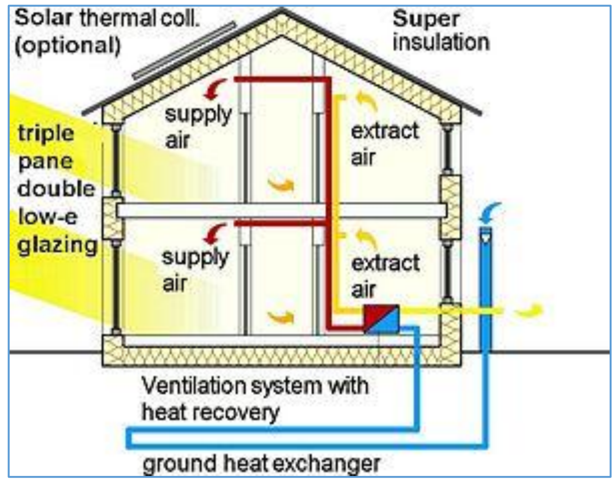


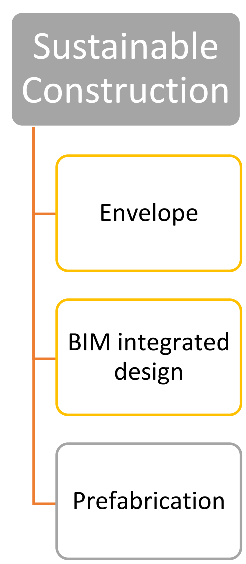
Figure 189 cooling tubes mechanism

4.7 Sustainable Construction

Modern Methods of Construction (MMC) bring possible panacea solutions for addressing time, quality and cost concerns often associated with 'traditional' construction. But cost and time have not been the only factors being paid attention to, but there is also sustainability as an important goal to achieve even during construction.

The sustainability in construction has two areas. One is the sustainability of the building itself, by the envelope and technological details for its construction, by the materials we used for it including recycled ones and in general the sustainability of building after its construction and eventual occupation. The other area of a sustainable construction, is the process of construction itself, which in large scale projects could take up to years , which can include issues like time of construction, methods such as offsite construction and an enhanced project management which can save energy and human and material resources.

We have also thought about providing a base for a sustainable construction whether about the building itself or the process of construction. The following chapters discuss the solution designed for achieving these goals and in the last chapter of section 4, we perform the calculation on the solution adopted on the project which have been designed based on the analysis done so far.



4.7.1 BIM integrated design

In phase of construction, a project which has been initially designed and developed within a bim based system, is likely to have much less errors during this phase and that is saving energy, time ,cost and human and natural resources.

According to Fruchter integration of design and construction process could better support collaboration within the global AEC teams, hence significantly decrease labor and material costs. This was further reinforced by Goulding et al., concerning the increased tendency of using ICT tools within design and construction, with the acknowledgement that design engineers are able to experiment and experience decisions in a 'cyber-safe' environment in order to mitigate or reduce risks prior to construction.

The abstract external design representation could provide the designers with great manipulative and instantaneously analytical autonomy without wasting their time and resources. This wasting could be inevitable if the ideas had to be tested directly at the building site. The research will try to determine necessary tool for a 'cyber-safe' environment and tries to utilize the right softwares for such a collaboration between all parties, assuming a real project, and adjusted the communication ways of people involved throughout the project lifecycle.

In this project as a complete architectural model has been built up in Revit, if it was to be really built, this model could be integrated with structural and mechanical information and become a complete tool of project management during the phase of construction.

Figure 190BIM model of the project

The 3D coordination can be started right after the model is created to ensure that any same space interference (hard clash) or clearance clash (soft clash) conflicts are resolved. Overall, the coordination efforts of construction manager and specialty contractors in advance of construction help to reduce design errors tremendously and to better understand ahead of time the work to be done.

The construction planning involves the scheduling and sequencing of the model to coordinate virtual construction in time and space. The schedule of the anticipated construction progress can be integrated to a virtual construction. The utilization of scheduling introduces time

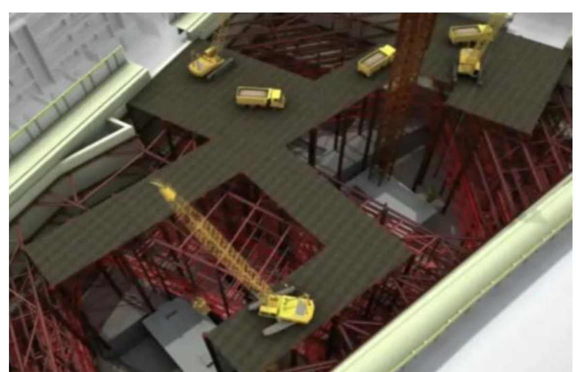


Figure 191 Hennesy Centre Safety and Site Logistics Planning (Collins, 2011)

as the 4th dimension (4D). The planning through using BIM enhances site utilization, space coordination, and product information.

4.7.2 Prefabrication :

If the way a building is going to be constructed, be thought of in early stages of conceptual design of the project, many advantages can be achieved such as better collaboration between architects and the contractors. This project has also adopted an architecture that could be realized and be adopted perfectly with new methods of construction, in particular, prefabrication.

In the United Kingdom (UK), where the government identified manufactured construction as a key tenet for improving construction in the 21st century, and was included the Egan's [84] report titled Rethinking Construction. In addition, the Industrialized Building System (IBS) in the UK is currently around 2% (£2-3bn pa) of the country's mainly run by fairly small companies.

Among the most important benefits of prefabrication is the concentration of human and natural resources in one facility , that is much better controlled than the site project, and building elemnts are produces in and standard industrialized way, with minimum human human errors respect to the conventional building methods.

The external envelope of the building specifically is greatly suitable to be prefabricated. External walls with integrated windows and other architectural elements could be easily and fast assembled on a site-built structure. Through a combination of CAM and CAD, architects now have a means of involving themselves in the factory production of the elements they have designed. The preferable method for production of walls, might be an envelope consisting of different layers that could be chosen according to energy efficiency needs and climate conditions. Since the structure and envelope can function separately in such a building, this can result a better acoustical and thermal insulation. Thus there are many advantages in this method of construction that makes it perform with high efficiency and lower construction costs.

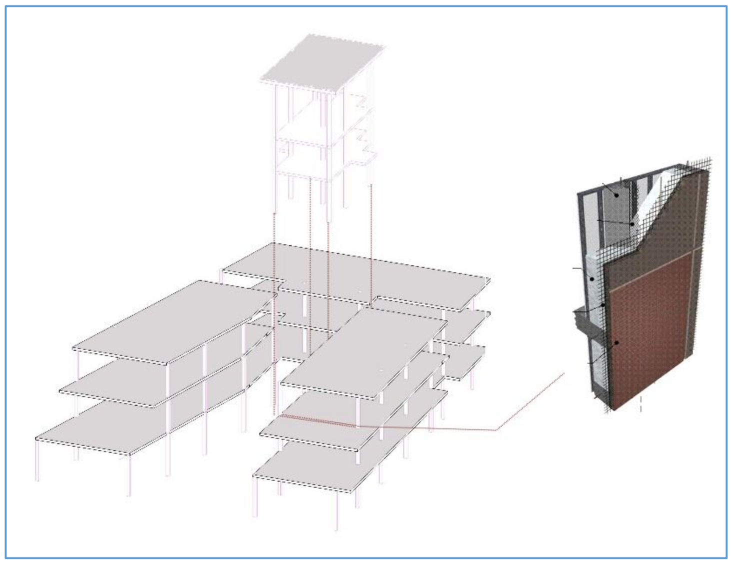


Figure 192 prefabricated walls and onsite structure

There are various methods and scales of prefabrication that regional conditions and cost advantages could determine different construction systems such as:

Pre-fabricated brick wall element with pre-cast concrete floor and stairs

Prefabricated aerated concrete panels with aerated concrete floor elements.

[84] Egan, J., *The Egan Report - Rethinking Construction, Report of the Construction Industry Taskforce to the Deputy Prime Minister*,. 1998

Expanded-clay-concrete wall panels with solid concrete floors.
Large format sand-lime brick elements with filigree floor elements.
Timber-stud elements complete with finishes and fittings.[85]
Energy-efficient, economical and durable building materials are essential for sustainable construction practices.
Our preferred method of construction is an on-site built concrete structure, on which the envelope will be mounted, in form of prefabricated panels.
As seen in the figure, after the completion of structure, the wall panels which are designed in different layers according our energy needs, sustainability of materials and most use of recycled materials.
In this way the construction time and cost will be much shortened, as the installation takes not a very long time and while the structure is being built, simultaneously the walls could be fabricated in its fabrication factory.
The integration of BIM systems is an advantage also for a construction method based on prefabrication, where all the prefabricated elements, such as wall panels, could be precisely modeled and engineered in a BIM based program. This way the contractors can use the BIM and generate details for the product in their fabrication software. Once the details are approved, the products can be fabricated using Computer Numerical Control (CNC) machines. Furthermore, the construction managers must administer the procurement schedule of the products. Overall, the prefabricated products must be delivered to the jobsite on time.
Curtain wall systems whether panelized or stick system, can be used with BIM to prefabricate parts and components. Panelized curtain wall systems may be considered for the schedule purposes. Stick systems require the use of assembly of each one of Components onsite whereas the panelized systems already come prefabricated with all the components which includes, insulation, glazing, stone, framing, etc.
As depicted in figure and presented in the BIMForum Conference in San Diego, virtual mock ups can be used to review 3D shop drawing of the building envelope[86]. The virtual mock ups

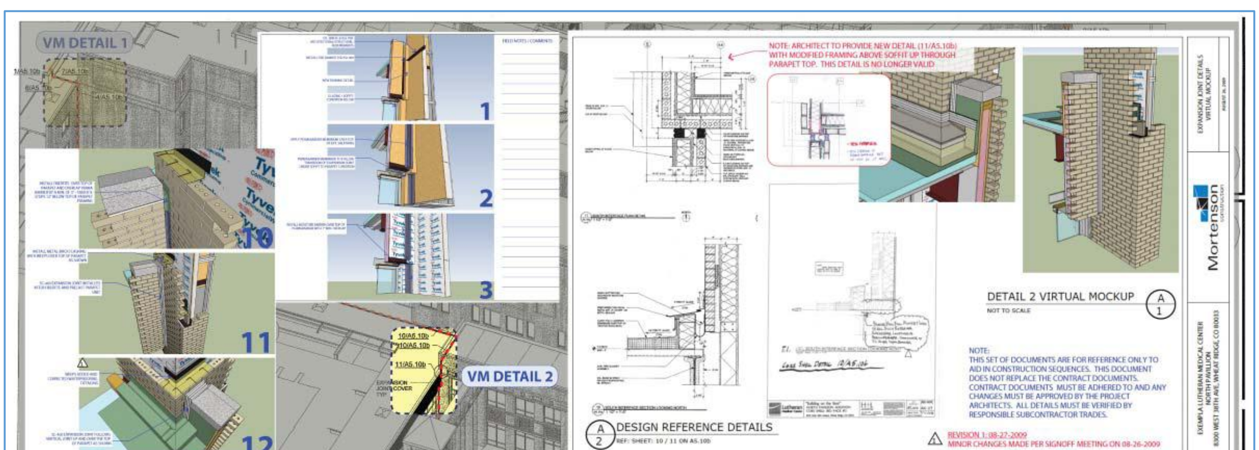


Figure 193 mock up of an evelope

[85] In Detail-cost effective buildings, economic concept and construction, Chrictian Schittich-p.66,67
[86] Khemlani, Lachmi. "AGC's Winter 2011 BIMForum, Part 1." *AECbytes "Building the Future"* (2011). Web. 22 Mar. 2011. <aecbytes.com>

help to communicate and collaborate among the project participants. It promotes planning, and sequencing the curtain wall construction. Even though a virtual mock up is cost efficient in comparison to a physical mock-up, a physical mock-up may still be required if a member such as an assembly of the building element such as a curtain wall need to go through a series of physical tests.

As discussed in this chapter, even though these project is not really going to be built , but during the design process a BIM based design was integrated into the process to show case the capabilities of it in real construction world, and not only as even during preparing the analysis for this thesis project, the BIM model could help us greatly to obtain different information needed for analysis and great visualization whether for architectural presentation or technical visual information, similar to the mock up system presented above.

BIM can be used to enhance the information exchange of the products between participations. Furthermore, it is used to virtually coordinate the location and routing of the products. Based on this information, the products can be detailed using the fabrication softwares.

Once the material is prefabricated and arrives on site, the foreman of the specialty trade coordinates with the general superintendent to ensure that he is making the virtual design and construction a reality.

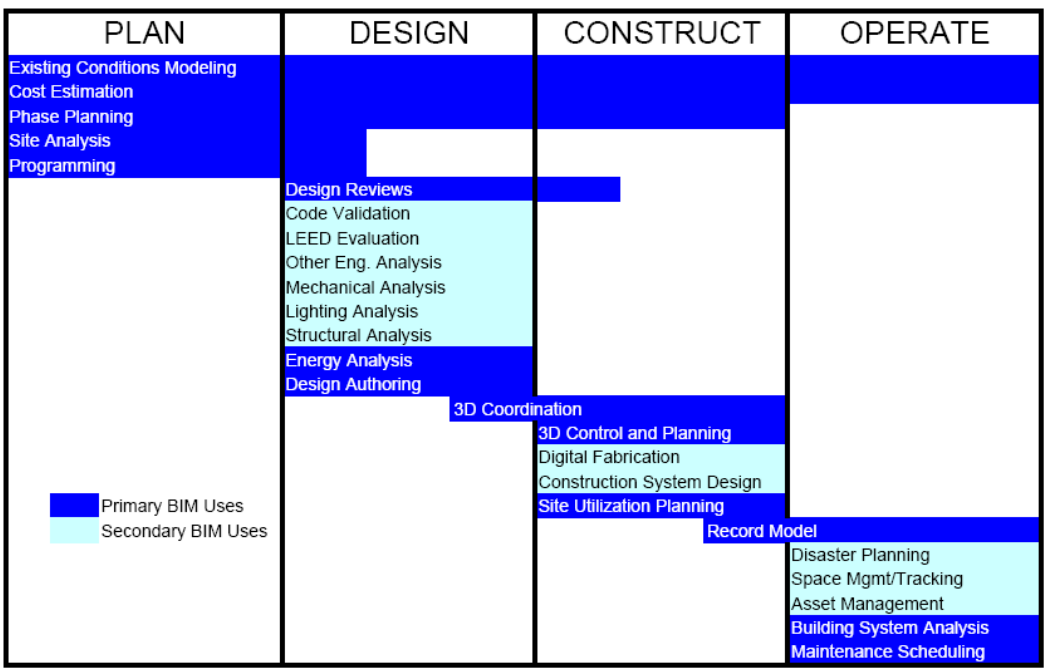
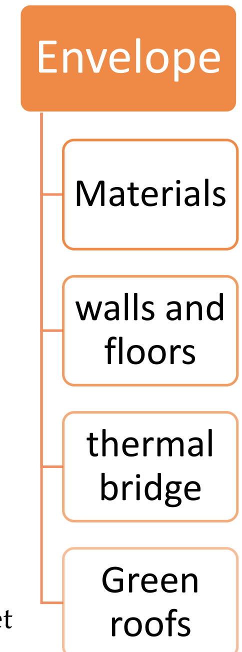


Figure 194 BIM Uses throughout a Building Lifecycle (Messner, 2009)

4.7.3 Building Envelope:



The envelope of a building is decisive in determining how a building fits in to its environment. If it is perceived as a disruptive foreign body, as unobtrusive or an exciting enhancement of a residential district.
On the one hand the building envelope incorporates the zeitgeist (spirit of the time), on the other hand it must be timeless enough to still look good decades later. At the same time it also plays a major role in perceived comfort, establishing the connection between interior and exterior worlds. And, finally, it also has a decisive influence on the energy balance of a building.
If just having and economical point of view on the matter, we can count on great expectations. As we read: "The energy savings from these efficiency policies can cut the electricity bills of customers by a net $500 million in 2015. Net annual savings grow nearly five-fold to $2.2 billion in 2025. While these savings will require some public and customer investment, by 2025 net cumulative savings on electricity bills will reach $15 billion. To put this into context, an average household will save a net $5 on its monthly electricity bill by 2015 and $20 per month by 2025. These savings are the result of two effects. First, participants in energy efficiency programs will install energy efficiency measures, such as more efficient appliances or heating equipment, therefore lowering their electricity consumption and electric bills. In addition, because of the current volatility in energy prices, efficiency strategies have the added benefit of improving the balance of demand and supply in energy markets, thereby stabilizing regional electricity prices for the future." [87]

Materials:
The process of selecting materials for a building project is a challenging task. To evaluate a product, we begin with its life cycle. Consider the source of the product and the effects of its extraction or manufacture. The question that may raise around the subject could be how it will be transported to the building site (and from what distance), how long the product will last, and what you will do with the material at the end of its useful life. By evaluating materials in this manner, you will be able to clearly identify concerns.
To assure the insulation level and achieving the desired u-value, a range of product are chosen to form the layers of the wall panels. These sheets will be placed on together and packed in metal frames, in sizes according to the architectural designs, and then transported to the site of installation on the structure.
What is Thermal Conductivity Coefficient?

[87] American Council for Energy-Efficient Economy , Research Report E085

thermal conductivity (often denoted k, λ, or κ) is the property of a material to conduct heat. It is evaluated primarily in terms of Fourier's Law for heat conduction. The dimension of thermal conductivity is M1L1T−3Θ−1. These variables are (M)mass, (L)length, (T)time, and (Θ)temperature. In SI units, thermal conductivity is measured in watts per meter kelvin (W·m−1·K−1). In Imperial units, thermal conductivity is measured in BTU/(hr·ft·°F).
For general scientific use, thermal conductance is the quantity of heat that passes in unit time through a plate of particular area and thickness when its opposite faces differ in temperature by one kelvin. For a plate of thermal conductivity k, area A and thickness L, the conductance calculated is kA/L, measured in W·K−1 (equivalent to: W/°C). The thermal conductance of that particular construction is the inverse of the thermal resistance. Thermal conductivity and conductance are analogous to electrical conductivity (A·m−1·V−1) and electrical conductance (A·V−1).
There is also a measure known as heat transfer coefficient: the quantity of heat that passes in unit time through unit area of a plate of particular thickness when its opposite faces differ in temperature by one kelvin. The reciprocal is thermal insulance. In summary:
thermal conductance = kA/L, measured in W·K−1
thermal resistance = L/(kA), measured in K·W−1 (equivalent to: °C/W)
heat transfer coefficient = k/L, measured in W·K−1·m−2
thermal insulance = L/k, measured in K·m2·W−1.
The heat transfer coefficient is also known as thermal admittance in the sense that is may be seen as admitting heat to flow.

-insulation: Building insulation materials are thermal insulation used in the construction or retrofit of buildings. The materials are used to reduce heat transfer by conduction, convection and radiation, are employed in varying combinations to achieve the desired outcome. Insulation material varies in type that includes fibers and different kinds of barrier.
There are four major rigid plastic foam insulations commonly used for residential, commercial and industrial insulation: extruded polystyrene (XEPS), expanded polystyrene (EPS), polyurethane (PUR), and polyisocyanurate (PIR). Each type has individual characteristics and specific advantages and disadvantages for particular building applications.

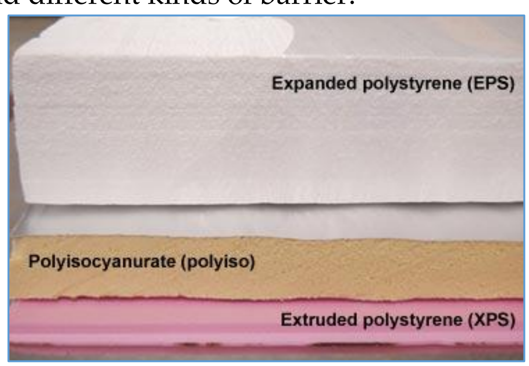


Figure 195 different pplystyrene sheets

Extruded polystyrene foam (XPS) :

Nonetheless, the stable properties of polystyrene, when combined with a unique foam extrusion process, produce an exceptionally useful product with benefits for nearly all construction and engineering applications.
Extruded polystyrene has a well established reputation for long-term reliability and superior resistance to the elemental forces of nature: time, water, cold, heat, and pressure.

It consists of closed cells, offers improved surface roughness and higher stiffness and reduced thermal conductivity. The Because of the extrusion manufacturing process, XPS does not require facers to maintain its thermal or physical property performance. Thus, it makes a more uniform substitute for corrugated cardboard. Thermal resistivity is usually about 35 m·K/W[but can range between 29 and 39 m·K/W[citation needed] depending on bearing/density.
Thermal conductivity varies between 0.029 and 0.039 W/(m·K) depending on bearing strength/density and the average value is ~0.035 W/(m·K).
Water vapor diffusion resistance (μ) of XPS is around 80–250 and so makes it more suitable to wetter environments than EPS.

Thermal conductivity	~0.035 W/(m·K)
Density range	28–45 kg/m3
Thermal resistivity	29- 39 m·K/W
Water vapor resistance	80–250

Rockwool:

Rockwool insulation, also known as stone wool or mineral wool insulation, is an insulation material made from molten rock. Stone fibers are heated up to a temperature of 1600 degrees Celcius and run through a spinning chamber which produces a cotton-candy like texture. The finished product is an excellent thermal insulation material, offering a high R-value, a lower environmental impact than many other insulation products, and a high level of fire resistance and durability.
We have adopted one layer of 50mm of extruded polystyrene sheets and two layers of Rockwool each with a thickness of 10mm , giving us a total insulation of 25 cm of mixed materials. Combined with structural elements and finishing, we will be able to calculate the overall u-value of our project.

Thermal conductivity	30-40 mW/m °K
Density range	56kg/m3
Thermal resistivity	9 m·K/W
Moisture Sorption	% 0.03

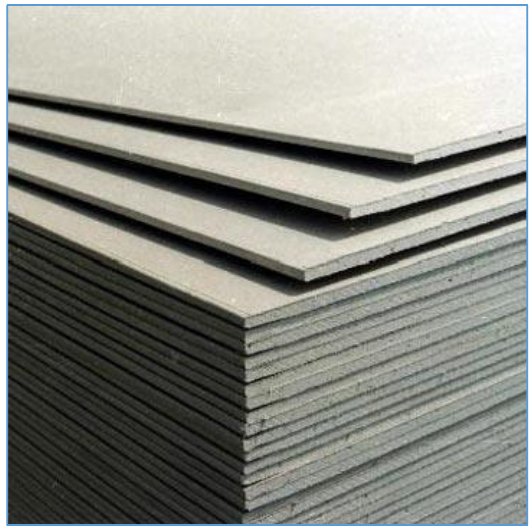
-structural element: As we have adopted a thick layer composed of insulation layers, we need to reduce as much as possible the thickness of structural element in the panels, to achieve an overall acceptable thickness.
Glass Fiber Reinforced Concrete (GFRC) is a type of fiber reinforced concrete. Glass fiber concretes are mainly used in exterior building façade panels and as architectural precast concrete. Somewhat similar materials are fiber cement siding and cement boards.
Glass fiber reinforced concrete (GFRC) consists of high strength glass fiber embedded in a cementations matrix. In this form, both fibers and matrix retain their physical and chemical identities, while offering a synergism: a combination of properties that cannot be achieved with either of the components acting alone. In general, fibers are the principal load-carrying members, while the surrounding matrix keeps them in the desired locations and orientation, acting as a load transfer medium between them, and protects them from environmental damage. In fact, the fibers provide reinforcement for the matrix and other useful functions in fiber-reinforced composite

Flexural strength—psi	5.17 Mpa
Weight range	15 kg/m2
Thermal R/k value	0.26/1.92
Moisture Sorption	% 0.03

materials. Glass fibers can be incorporated into a matrix either in continuous lengths or in discontinuous (chopped) lengths.

-**Interior finishing :** in order to complete the prefabricated panels with a clean surface ready to receive the final layers of finishing such as painting or wallpaper, we have closed plasterboard for such a purposes, where guarantees a clean surface on the inner side of the prefabricated dry wall.

Plasterboard is a panel made of gypsum plaster pressed between two thick sheets of paper. It is used to make interior walls and ceilings. A wallboard panel is made of a paper liner wrapped around an inner core made primarily from gypsum plaster. The raw gypsum, $CaSO4·2\ H2O$, (mined or obtained from flue-gas desulfurization (FGD)) must be calcined before use to produce the hemihydrate of calcium sulfate ($CaSO4·½\ H2O$). This is done in kettle or flash calciners, typically using natural gas today. The plaster is mixed with fiber (typically paper and/or fiberglass), plasticizer, foaming agent, finely ground gypsum crystal as an accelerator, EDTA, starch or other chelate as a retarder, various additives that may decrease mildew and increase fire resistance (fiberglass or vermiculite), wax emulsion or silanes for lower water absorption and water. This is then formed by sandwiching a core of wet gypsum between two sheets of heavy paper or fiberglass mats. When the core sets and is dried in a large drying chamber, the sandwich becomes rigid and strong enough for use as a building material.



-**Vapor Barrier**: A vapor barrier (or vapor barrier) is often used to refer to any material for damp proofing, typically a plastic or foil sheet, that resists diffusion of moisture through wall, ceiling and floor assemblies of buildings and of packaging. Technically, many of these materials are only vapor retarders as they have varying degrees of permeability.

Materials have a moisture vapor transmission rate that is established by standard test methods. One common set of units is $g/m^2·day$ or $g/100in^2·day$. Permeability can be reported in perms, a measure of the rate of transfer of water vapor through a material (1.0 US perm = 1.0 grain/square-foot·hour·inch of mercury ≈ 57 SI perm = 57 ng/s·m2·Pa). American building codes have classified vapor retarders as having a water vapor permeance of 1 perm or less when tested in accordance with the ASTM E96 desiccant, or dry cup method.

as it was necessary to use a vapor barrier to avoid condensation risks on the surfaces, we used a membrane of aluminum foil which as placed between the layers of plasterboards.

-exterior finishing: Stone cladding is a thin layer of stone or simulated stone applied to a building or other structure made of a material other than stone. Stone cladding often refers to lightweight simulated stone products with a concrete type base. These stone cladding products are often fitted to light weight substrates to reduce the material cost of construction.

Thermal conductivity	1.7 W/m °K
Density range	2515 kg/m3
Specific heat capacity :	1000 j /kgK

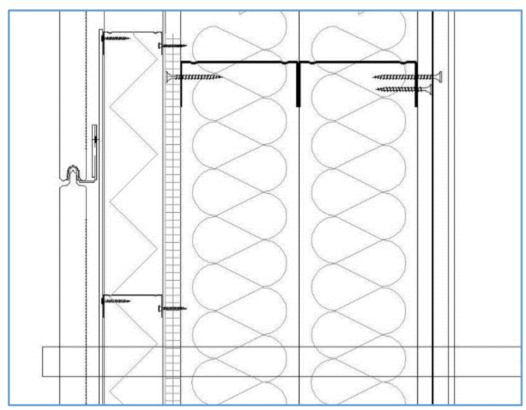
A lightweight substrate would typically be a timber stud frame, it would then have a waterproof barrier attached, then fiber cement sheet, expanded metal mesh, a mortar scratch coat, and then using a mortar mix, the stone cladding would be adhered to the wall. In our prefabricated wall panels the layer of 3cm thick stone is placed on the most outer layer by its designated particular details.

-Wall panels- Exterior Walls:

With a selection and combination of the materials seen above, we can design our multi-layer wall panel system that are to be mounted on the onsite built structure. We mentioned the selected materials for different functions to achieve our desired goals.

the prefabricated wall panel is consisted of these layers below, framed into a metal lightweight structure: in order from right-left (inside to outside):

Paint 3mm
Plasterboard 12.5mm
Vapor barrier (aluminum foil) 1mm
Plasterboard 12.5mm
Insulation (rock wool) 100mm
Insulation (rock wool) 100mm
Fiber cement board 10mm
Adhesive layer 2mm
Extruded polystyrene board 50mm
Stone 30mm



We later imported the data of the layers and selection of materials, by finding the commercial replacement, into a calculation engine offered by the German site U-wert.net. the website offers a number of online analysis which are real time, fast and precise, making it a great tool especialy to compare different solutions. Following we present some more important data resulted from the analysis based by the wall layers we imported in its input form.

Layers (from inside to outside)

Folgende Tabelle enthält die wichtigsten Daten aller Schichten der Konstruktion:

#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	max	Weight [kg/m²]	Condensate [Gew%]
		Thermal contact resistance		0,130	19,5	20,0		
1	1,25 cm	Plasterboard (12,5mm)	0,210	0,060	19,2	19,5	9,9	0,0
2	0,12 cm	AirGuard® Reflective	0,500	0,002	19,2	19,2	1,2	0,0
3	1,25 cm	Plasterboard (12,5mm)	0,210	0,060	19,0	19,2	9,9	0,0
4	10 cm	Coverrock	0,036	2,778	7,5	19,0	10,0	0,0
5	10 cm	Coverrock	0,036	2,778	-3,9	7,5	10,0	0,0
6	2 cm	Concrete	2,000	0,010	-3,9	-3,9	48,0	0,0
7	5 cm	ROOFMATE SL-A 30-60mm	0,035	1,429	-9,8	-3,9	1,6	0,0
8	3 cm	Granit	2,800	0,011	-9,8	-9,8	78,0	0,0
		Thermal contact resistance		0,040	-10,0	-9,8		
	32,62 cm	Whole component		7,294			168,6	

Figure 196 layers properties

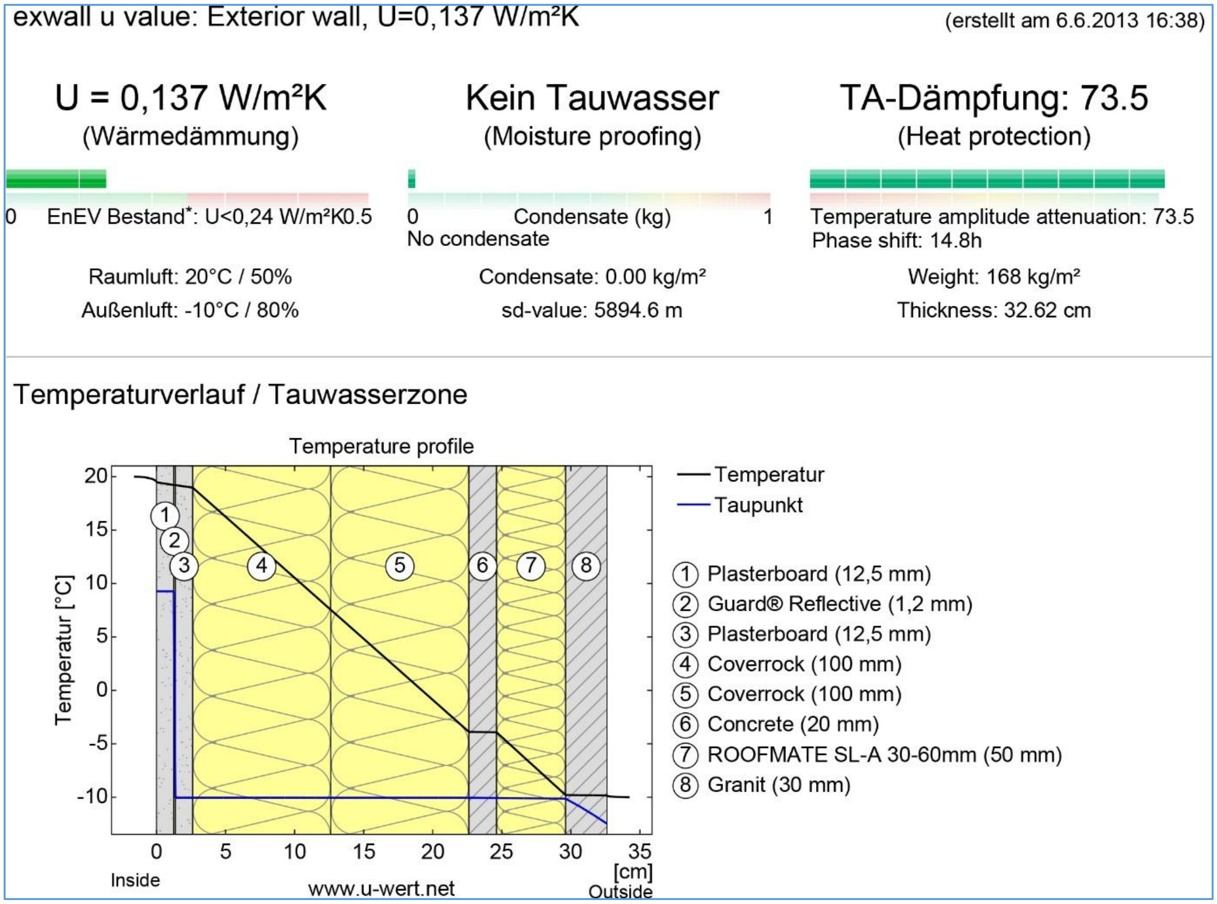


Figure 197 facts visualization

In the figure above we can see some important facts about the wall panel designed for the façade. Here we see some acceptable results. The U-Value of 0.137 W/m2K shows a good level of insulation. The software has also analyzed the condensation risks. As our layer number two is a vapor barrier, Moisture proofing shows no risk of condensation as the Temperature line and Dew point line don't intersect each other. The hear protection is also 73.5 .

The wall panels will have a weight of 168 kg/m2 and a thickness of 32 to 35 cm. The figure below shows the U-Value range achieved by different system and experiences. As seen our you value is quite close the passivehaus one that has a U-Value about 0.1 W/m2K.

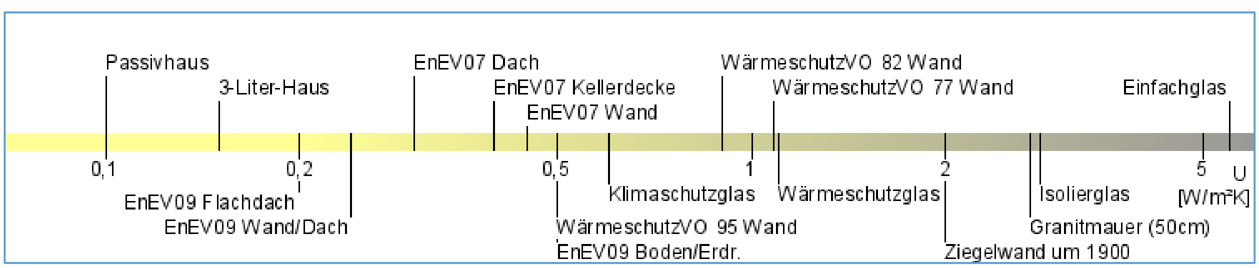


Figure 198 U-Value Range of different projects

Relative Humidity: The surface temperature of the inner side wall is 19.5 ° C resulting in a relative humidity at the surface of 52% results. Under these conditions, should not be expected to mold growth.The following diagram shows the relative humidity within the component. Outside of this component corresponds to the size of the relative humidity. The drop of RH is obvious where the vapor barrier is placed between the two plaster boards.

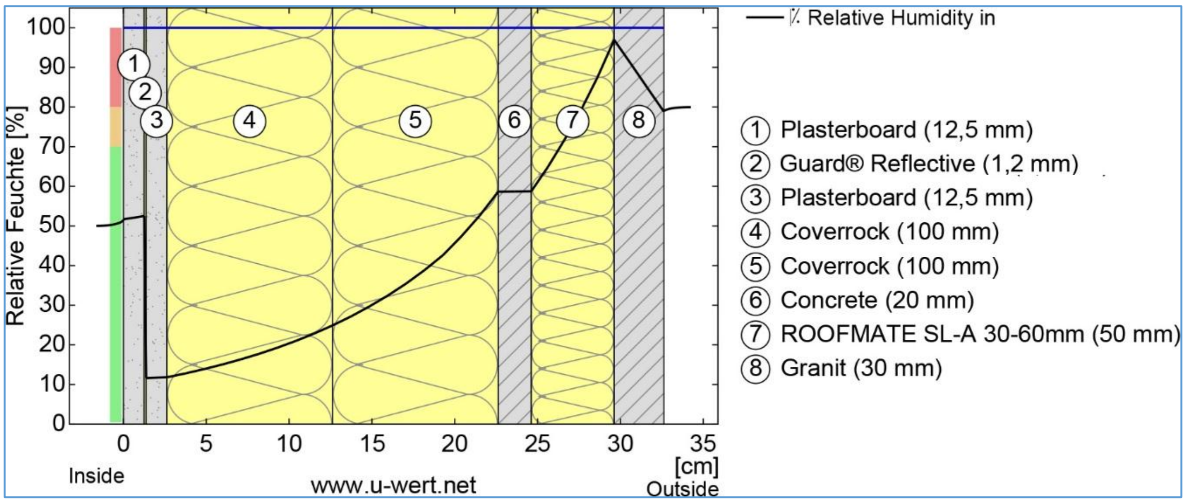


Figure 199 relative humidity diagram

Heat Protection: For the analysis of the summer heat protection temperature changes within the component were in the course of a hot summer day simulated. The following table shows the results:

Phase shift: 14.8 h	when the maximum internal temperature: 6:30
Amplitude attenuation: 73.5	Temperature difference on the outer surface of 19.1 ° C
TAV: 0.014	on inner surface temperature difference: 0.3 ° C

The phase shift indicates the time in hours, after which the afternoon heat, the maximum Reaches inside of the component. The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 indicates that the temperature on the outside varies 10 times stronger than on the Inner e.g. 15-35 ° C outside, inside 24-26 ° C. The temperature TAV amplitude ratio is the inverse of the damping: TAV = 1/ attenuation of amplitude)

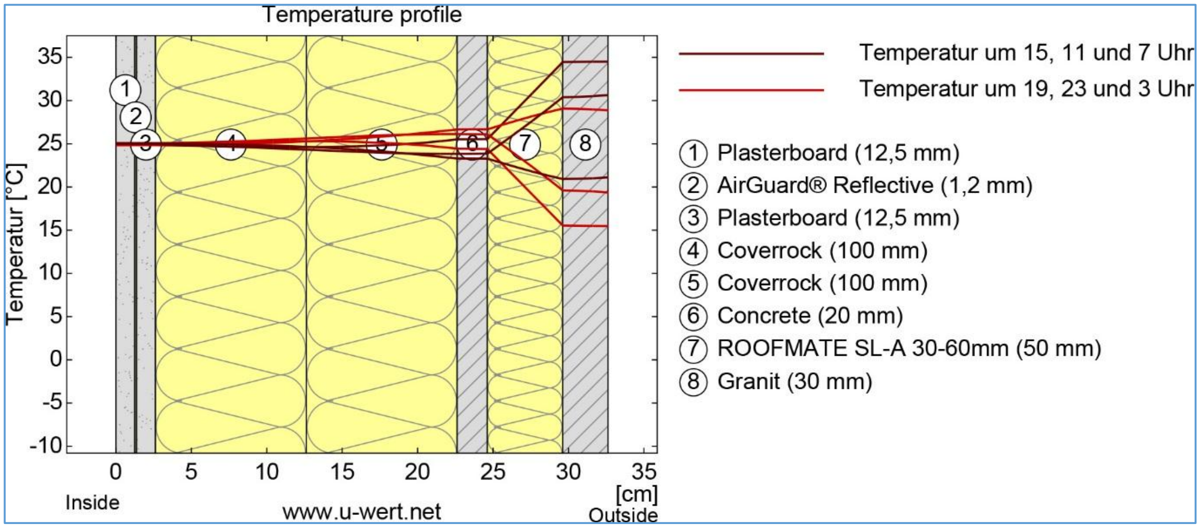


Figure 200

Upper figure: temperature profile within the component at different times. From top to bottom, brown lines: 15, 11 and 7 clock and red lines at 19, 23 and 3 clock in the morning.
Lower illustration: temperature on the outer (red) and inner (blue) surface in the course of a day. the black Arrows indicate the position of the temperature maximum values. The maximum of the inner surface temperature should be as occur during the second half of the night.

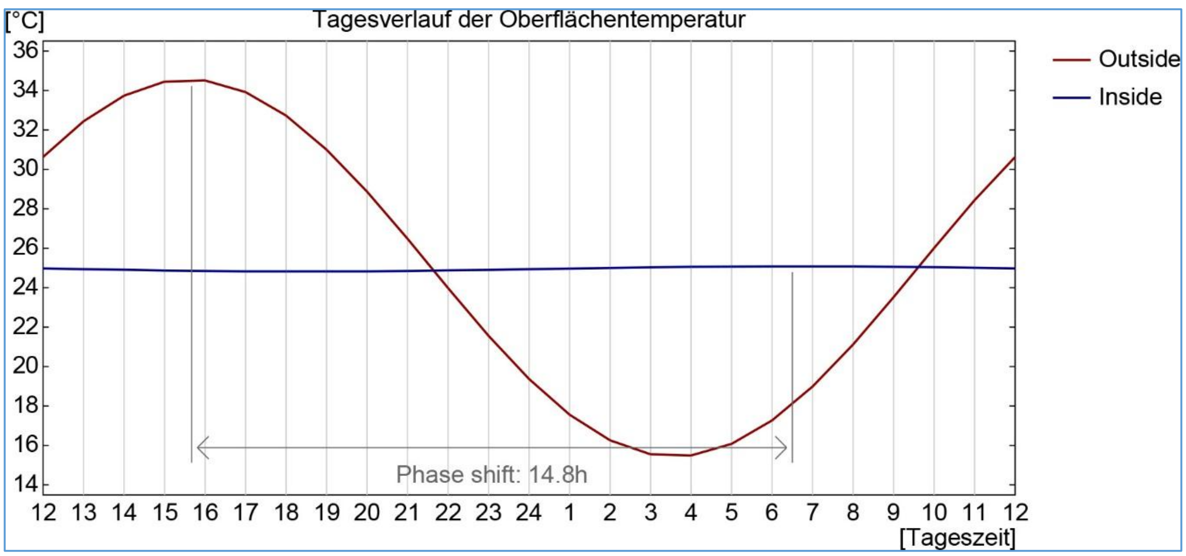


Figure 201

Heat storage capacity: Heat capacity of the entire component: 148 kJ / m² K or 0,041 kWh / m² K (KJ energy in kWh and that receives one of the square member when indoor and outdoor temperature by 1 ° C at the same time can be increased.)
Heat storage capacity of the internal layers: 41 kJ / m² K or 0,011 kWh / m² K
(KJ energy in kWh and that receives a square meter of the component, when the inner temperature is increased by 1 ° C and Outside temperature is maintained.)

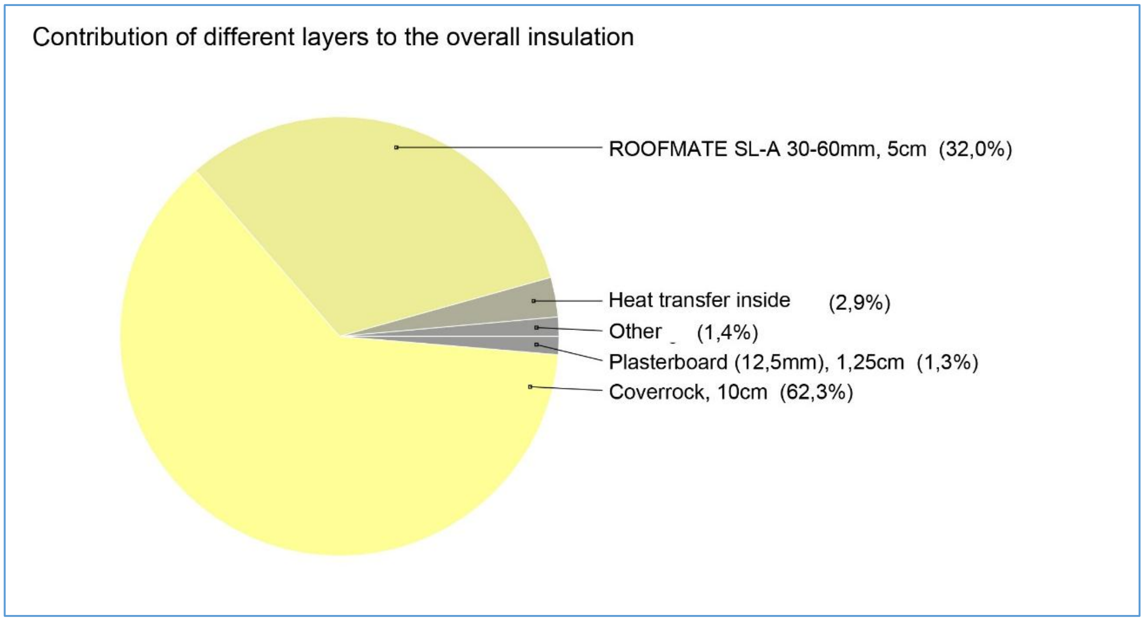


Figure 202 layers insulation

-Wall Panels-Interior walls:

Obviously the interior walls do not need to have an insulation level as high as exteriors. We have designed the detail of the interior walls with a selection of materials discussed above, resulting in a muiltilayer dry wall system that like the exterior ones will be prefabricated. An insulation layer has been employed in the wall as they maybe adjacent to an unheated room or corridor or the temperature differences between spaces according to controls of users.
Here we see an example of the internal walls, being in between bath and corridor.

2-from left to right:
Ceramic tiles 12.5mm

Tile mortar 5mm

Fiber cement board 12.5mm

Sand layer w/heating inserts 30mm

Polystyrene insulation layer 20mm

Polyethylene vapor barrier 1mm

Acoustical lining 5mm

Concrete slab 100mm

Plasterboard 12.5mm

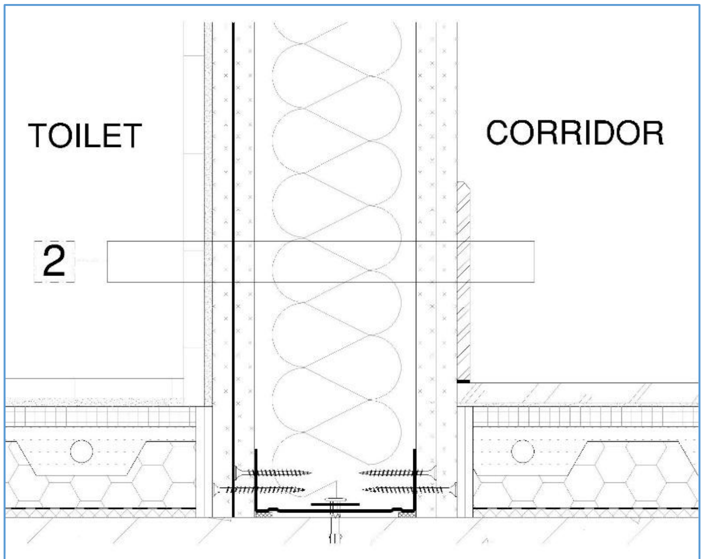


Figure 203 internal wall detail

Also in this case we performed a number of analysis by u-wert web site, designing a general internal wall in its system. So not like the detail above, we won't have tiles or other finishing, but just a normal plasterboard surface as the general internal wall for this analysis. The hotter space is considered 20 degrees and the least heated one is considered 15 degrees.

Layers (from inside to outside)

#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	Temperatur [°C] max	Weight [kg/m²]	Condensate [Gew%]
		Thermal contact resistance		0,130	19,8	20,0		
1	1,25 cm	Plasterboard (12,5mm)	0,210	0,060	19,7	19,8	9,9	0,0
2	1,25 cm	Plasterboard (12,5mm)	0,210	0,060	19,6	19,7	9,9	0,0
3	10 cm	Coverrock	0,036	2,778	15,2	19,6	10,0	0,0
4	1,25 cm	Plasterboard (12,5mm)	0,210	0,060	15,2	15,2	9,9	0,0
5	1,25 cm	Plasterboard (12,5mm)	0,210	0,060	15,1	15,2	9,9	0,0
		Thermal contact resistance		0,040	15,0	15,1		
	15 cm	Whole component		3,186			49,5	

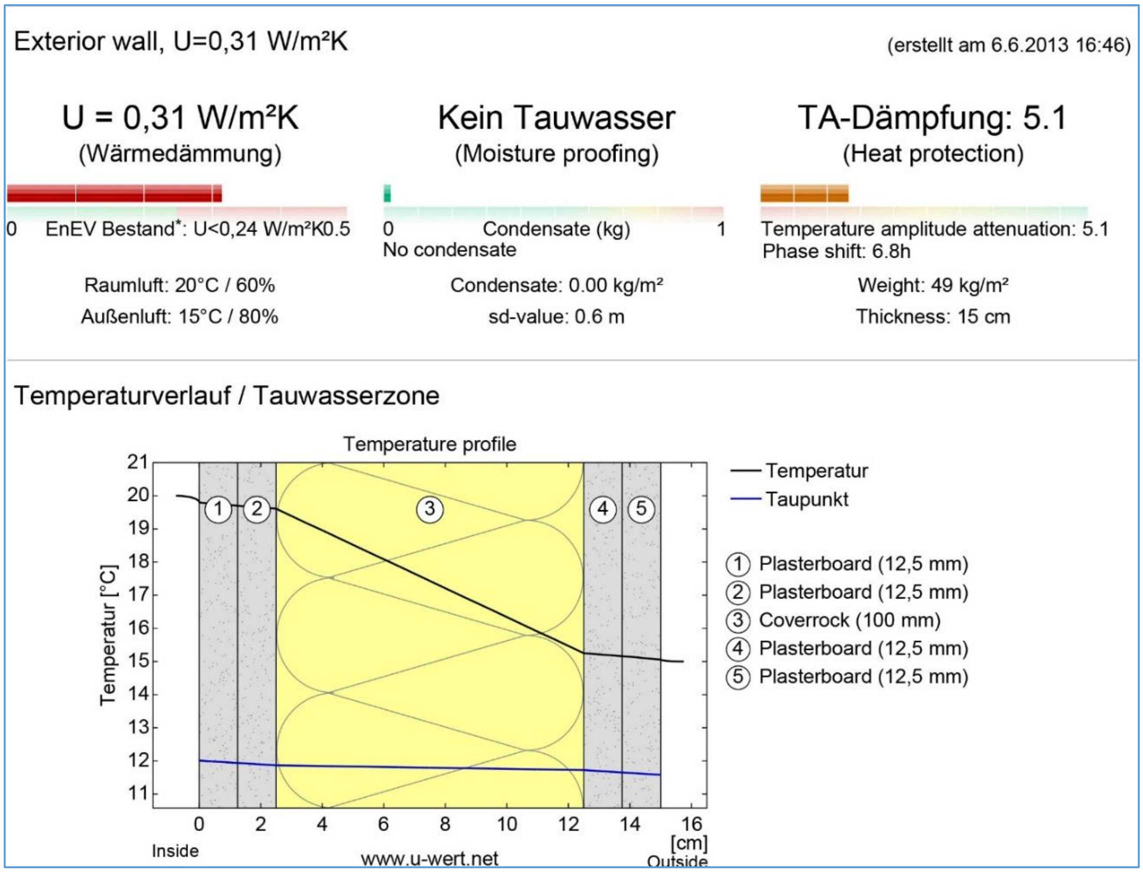


Figure 204 i9nternal wall properties

Course of temperature and dew point within the component. The dew point indicates the temperature at which Condense water vapor and condensation would occur. As long as the temperature of the structure at each point on the dew point is, there is no condensation. If the two curves touch, falls at the contact points Condensation from.

As we see the wall offers a U-Value of 0.31 W/m2K which for an internal wall is acceptable. No condensation will happen at such a temperature difference and it will have a thickness of 15 cm and weighs up to 49 kg/m2 .

Relative Humidity : The surface temperature of the inner side wall is 19.8 ° C resulting in a relative humidity at the surface of 61% results. Under these conditions, should not be expected to mold growth. The following diagram shows the relative humidity within the component. Outside of this component corresponds to the size of the relative humidity.

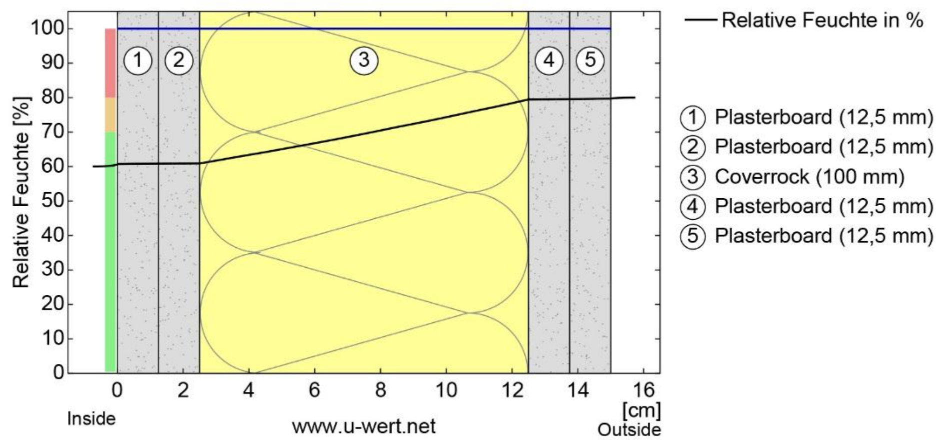


Figure 205 relative humidity

Heat protection: For the analysis of the summer heat protection temperature changes within the component were in the course of a hot summer day simulated. The following table shows the results:

Phase shift: 6.8 h	ime of maximum internal temperature: 22:00
Amplitude attenuation: 5.1	temperature difference on the outer surface: 19.6 °C
TAV: 0,195	temperature difference on inner surface: 3.8 ° C

(The phase shift indicates the time in hours, after which the afternoon heat, the maximum Reaches inside of the component. The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 indicates that the temperature on the outside varies 10 times stronger than on the Inner e.g. 15-35 ° C outside, inside 24-26 ° C. The temperature TAV amplitude ratio is the inverse of the damping:
TAV = 1/ attenuation of amplitude)

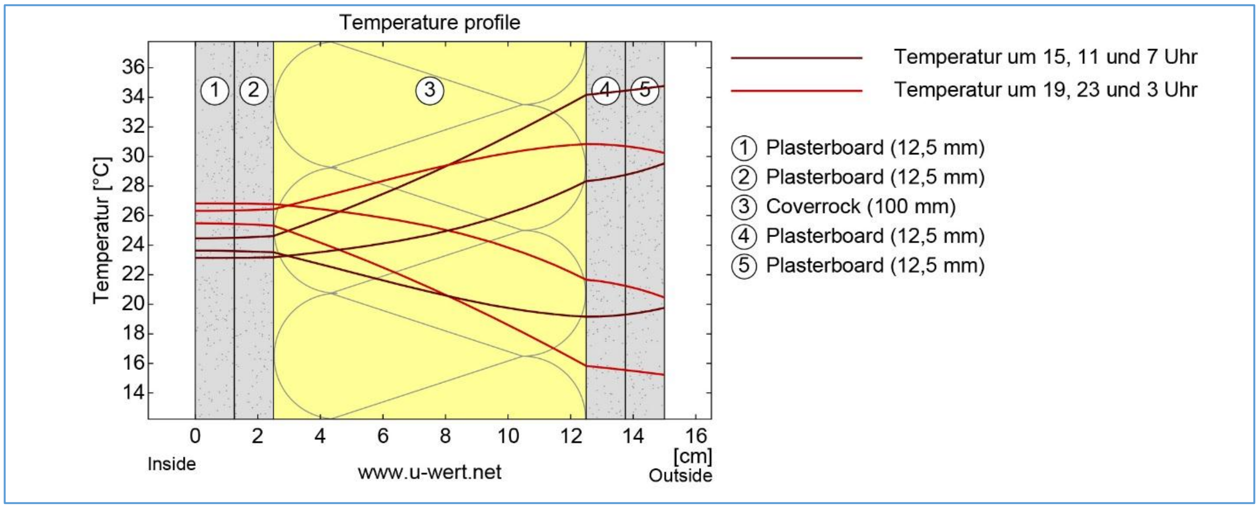


Figure 206 heat transfer

Up panel: temperature profile within the component at different times. From top to bottom, brown lines: 15, 11 and 7 clock and red lines at 19, 23 and 3 clock in the morning. Lower illustration: temperature on the outer (red) and inner (blue) surface in the course of a day. The black Arrows indicate the position of the temperature maximum values. The maximum of the inner surface temperature should be as occur during the second half of the night.

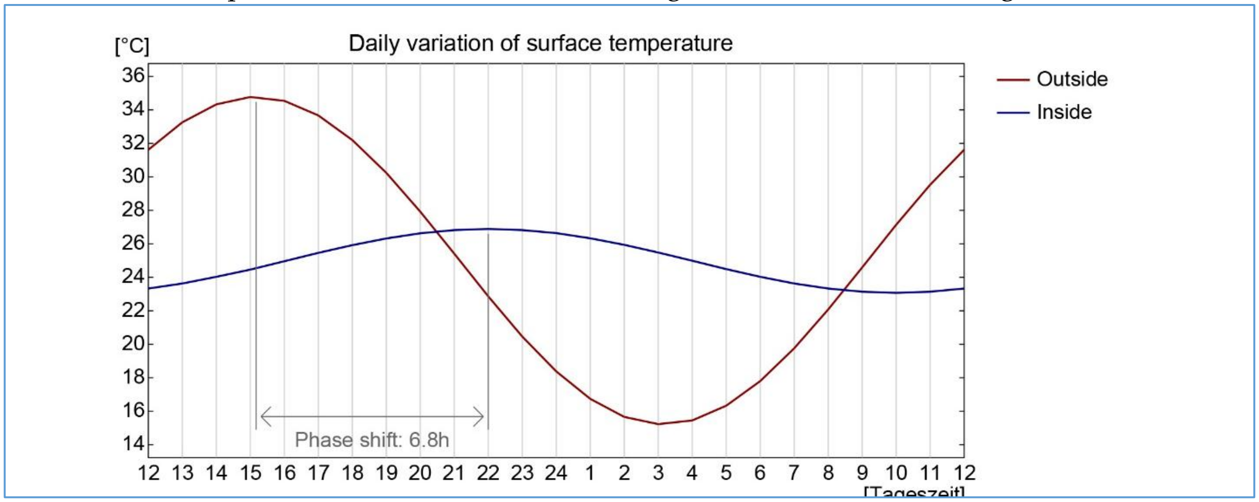


Figure 207 surface temprature

Heat storage capacity : Heat capacity of the entire component: 49 kJ / m² K or 0,014 kWh / m² K (KJ energy in kWh and that receives one of the square member when indoor and outdoor temperature by 1 ° C at the same time can be increased.)

Heat storage capacity of the internal layers: 24 kJ / m² K or 0.0067 kWh / m² K

(KJ energy in kWh and that receives a square meter of the component, when the inner temperature is increased by 1 ° C and Outside temperature is maintained.)

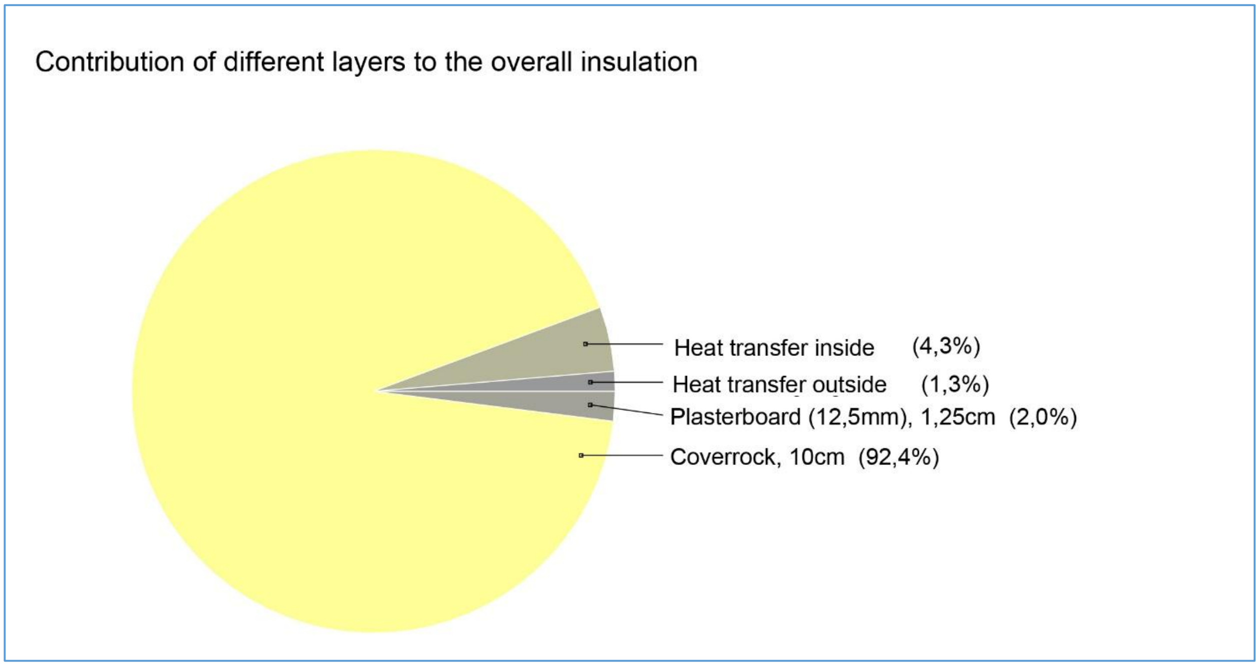


Figure 208 layers insulation

-Glazing : as an important character of our façade and architecture of the project, we have large areas of fenestrations, which are made by a kind of curtain wall system, attached between the two slabs and is made up of wooden Moulin's. The important parts of these fenestrations in energy point of view, are the mullions and their thermal resistance and the glass surface, the kind of glass and its properties.

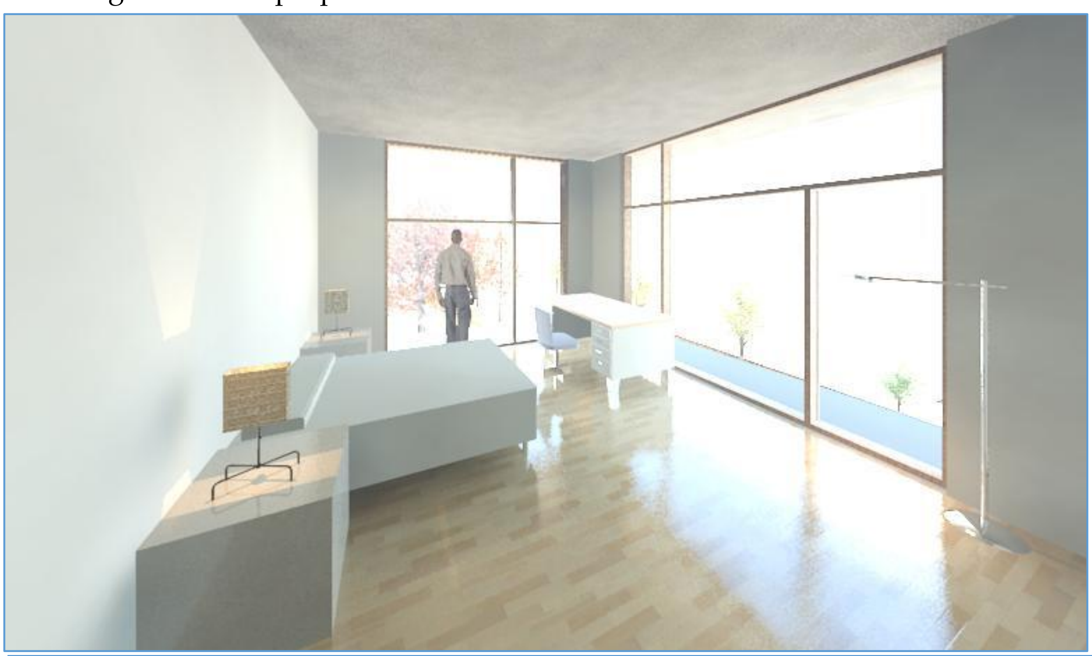


Figure 209 internal view of a Bedroom

The frames of the glasses and infect the mullions, which are made of wood have a good thermal resistance with a R Value of 2.17. for the glasses surfaces, we have chosen to use Low-emissivity glass (or low-e glass as it is commonly referred to) is a type of energy-efficient glass designed to prevent heat escaping through your windows to the cold outdoors. Low-e glass has an invisible coating which dramatically reduces heat transfer and reflects interior heat back into your room.

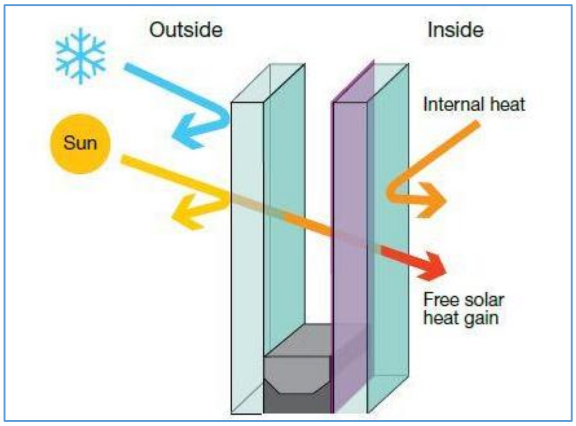


Figure 210 double glazing with e coating

Heat always flows towards the cold. Therefore, window glass without a low-e coating will absorb the heat from your home and radiate it onto the colder outside surface, where it is lost. Low-e glass has a special coating which is a poor radiator of heat and does not allow heat to be transferred to the outside. Instead, the low-e coating actually reflects the heat back into your room.

Low-e glass is essential for rooms or buildings with a high proportion of windows or glass doors, such as conservatories and sun rooms. The use of low-e glazing helps to retain heat even in winter, allowing you to comfortably use these rooms for more months of the year. Low-e glass is also recommended for north or east facing windows, where a larger proportion of heat loss would be expected. For south and west facing glazing where overheating can become a problem in the summer months, your installer may recommend the use of solar control glass.

-Floors : above the structural floors that are made of concrete slabs, we have different layers. The last outer layer is usually made of parquet, with exceptions like in the balconies or the bathrooms. Under the finishing layer, lays our heating system which is consisted of floor hot water pipes which are placed in a sand mortar and a layer of insulation is immediately placed under it, to stop heat escape downwards**.**

Parquet floor 12.5mm

Adhensive layer 2mm

Fiber cement board 12.5mm

Sand layer w/heating inserts 30mm

Polystyrene insulation layer 20mm

Polyethylene vapor barrier 1mm

Acoustical lining 5mm

Concrete slab 150mm

Plasterboard 12.5mm

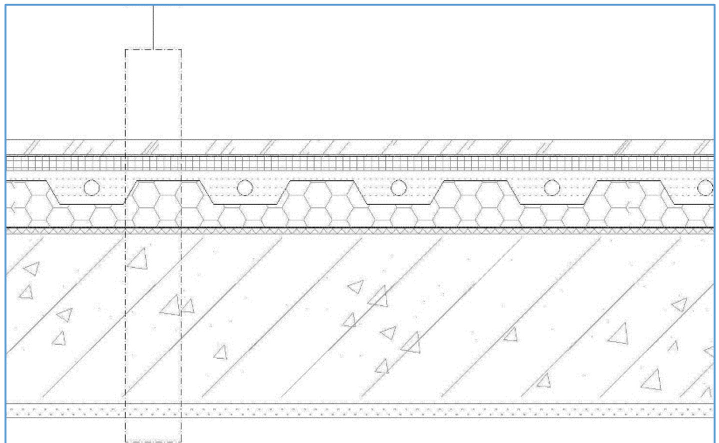


Figure 211 floor detail

also in case of floor we have imported the relative data into u-wert website and we have obtained a number of data about the floor properties and analysis related to its behavior. We have considered both spaces above and below the floor are heated.
like the walls, in the website we have chosen real commer4cial products which where most close to our selection of materials and functions. Here below you see the list:

#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	max	Weight [kg/m²]	Condensate [Gew%]
		Thermal contact resistance		0,170	19,2	20,0		
1	1,25 cm	Oak	0,180	0,069	18,8	19,2	8,6	0,0
2	0,2 cm	Lime render	0,870	0,002	18,8	18,8	2,8	0,0
3	1,25 cm	Light weight concrete	1,300	0,010	18,8	18,8	22,5	0,0
4	2,5 cm	Kalksandstein (Rohdichteklasse 1,2)	0,560	0,045	18,6	18,8	30,0	0,0
5	2,5 cm	Polyester thermal, sound insulation	0,045	0,556	15,9	18,6	4,0	0,0
6	0,1 cm	PE foil	0,400	0,003	15,8	15,9	0,9	0,0
7	15 cm	Concrete	2,000	0,075	15,5	15,8	360,0	0,0
8	1,25 cm	Plasterboard (12,5mm)	0,210	0,060	15,2	15,5	9,9	0,0
		Thermal contact resistance		0,040	15,0	15,2		
	24,05 cm	Whole component		1,029			438,7	

As the hypothesis of analysis, we considered the uper part of floor a well heated space of 20 degrees and the space below to 15 degrees of celcius.

As we can see in the figure, we have a U-value of 0.97 W/m2K which for these floor between two heated spaces are acceptable. We have no risk of condensation and the heat protection is at a high level of 9.7.

Relative Humidity: Under the assumed conditions, no condensation forms.

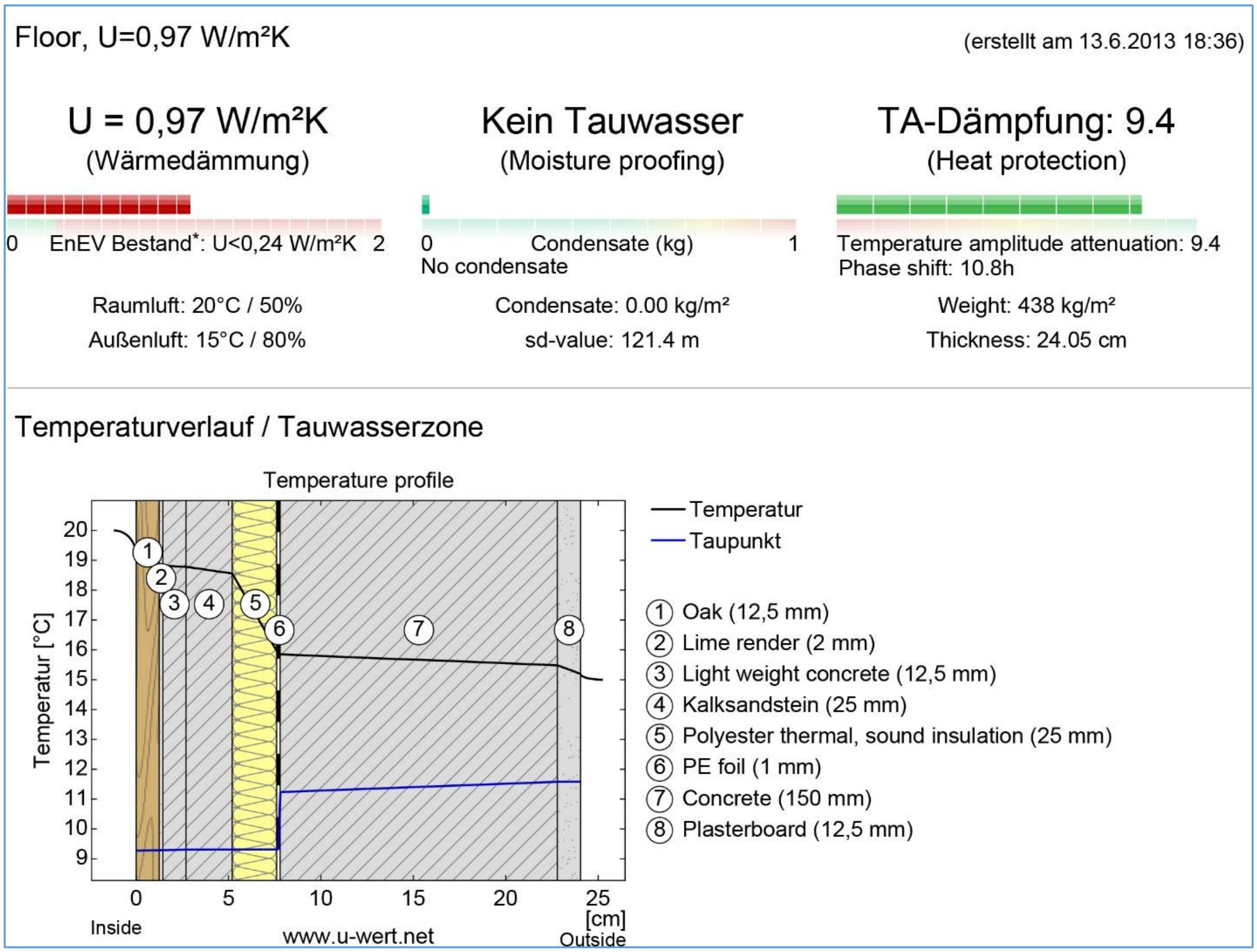


Figure 212 thermal characteristic of floor

Moisture proofing

Unter den angenommenen Bedingungen bildet sich kein Tauwasser.

#		Material	sd-value [m]	Condensate [kg/m²]	Condensate %	Time to dry Days	Weight [kg/m²]
1	1,25 cm	Oak	0,62	-	0,0		8,6
2	0,2 cm	Lime render	0,02	-	0,0		2,8
3	1,25 cm	Light weight concrete	0,88	-	0,0		22,5
4	2,5 cm	Kalksandstein (Rohdichteklasse 1,2)	0,12	-	0,0		30,0
5	2,5 cm	Polyester thermal, sound insulation	0,12	-	0,0		4,0
6	0,1 cm	PE foil	100,00	-	0,0		0,9
7	15 cm	Concrete	19,50	-	0,0		360,0
8	1,25 cm	Plasterboard (12,5mm)	0,10	-	0,0		9,9
	24,05 cm	Whole component	121,37	0,000		0	438,7

Figure 213 moisture proofing

The surface temperature of the inner side wall is 19.2 ° C resulting in a relative humidity at the surface of 53% results. Under these conditions, should not be expected to mold growth. The following diagram shows the relative humidity within the component. Outside of this component corresponds to the size of the relative humidity.

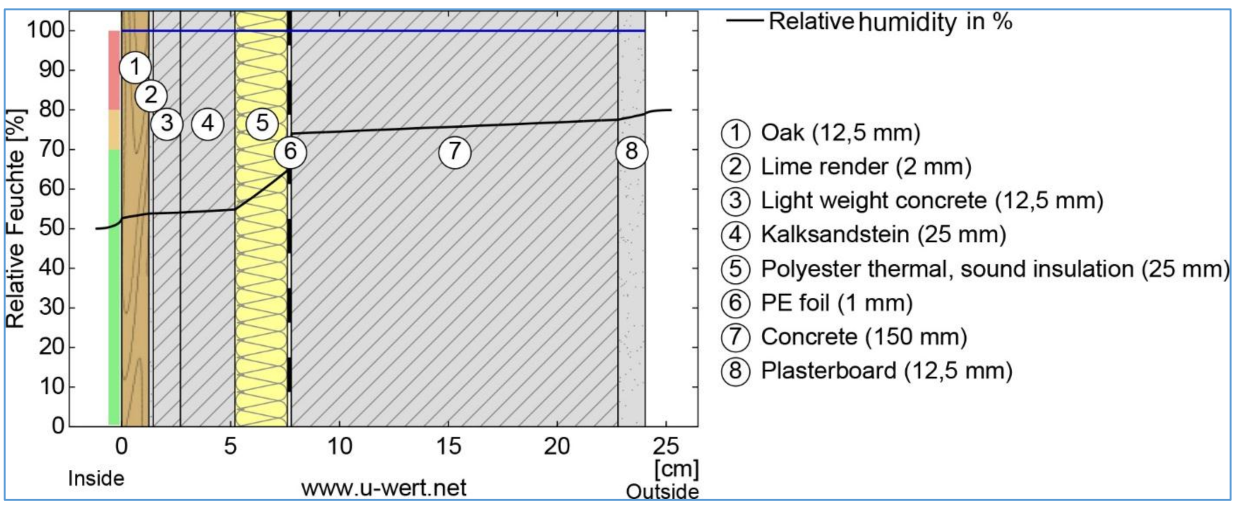


Figure 214 Relative humidity diagram

What is important to know from these analysis on relative humidity is to insure that no condensation will occur under the floors that the software confirms there under the assumed conditions there would be no condensation.

Heat protection: For the analysis of the summer heat protection temperature changes within the component were in the course of a hot summer day simulated. The following table shows the results:

Phase shift: 10.8 h	when the maximum internal temperature: 2:15
Amplitude attenuation: 9.4	temperature difference on the outer surface: 14.4 ° C
TAV: 0,107	temperature difference on inner surface: 1.5 ° C

(The phase shift indicates the time in hours, after which the afternoon heat, the maximum Reaches inside of the component. The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 indicates that the temperature on the outside varies 10 times stronger than on the Inner e.g. 15-35 ° C outside, inside 24-26 ° C. The temperature TAV amplitude ratio is the inverse of the damping: TAV = 1/ attenuation of amplitude)

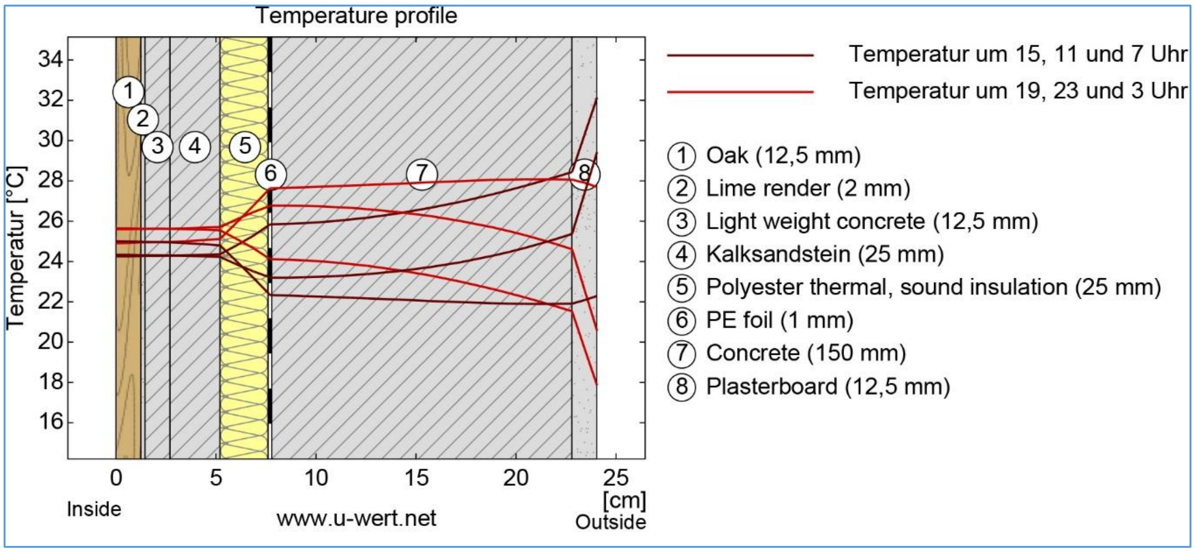


Figure 215 heat protection diagram

Upper figure: temperature profile within the component at different times. From top to bottom, brown lines: 15, 11 and 7 clock and red lines at 19, 23 and 3 clock in the morning.
Next illustration: temperature on the outer (red) and inner (blue) surface in the course of a day. The black Arrows indicate the position of the temperature maximum values. The maximum of the inner surface temperature should be as occur during the second half of the night.

Daily variation of temperature

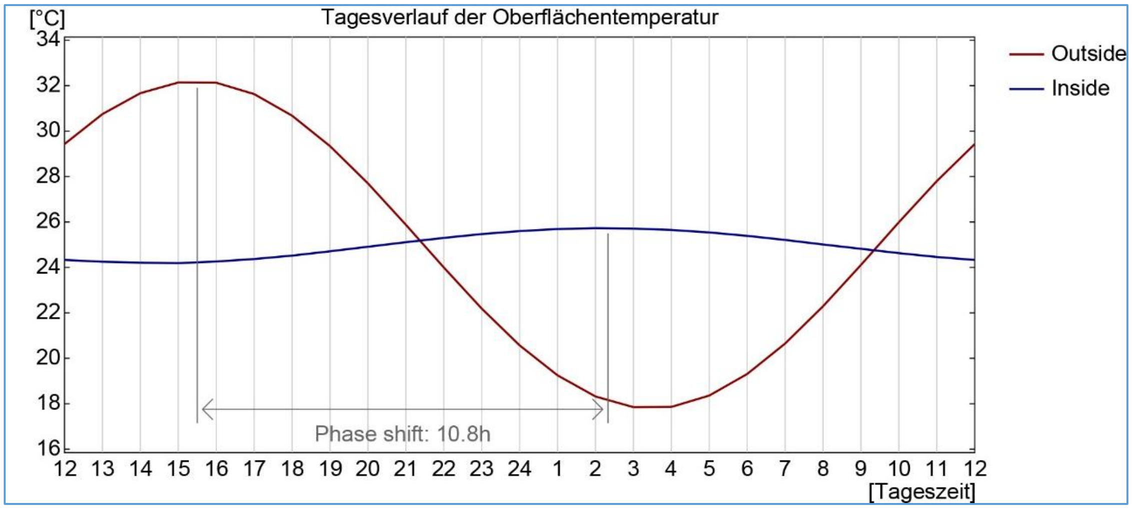


Figure 216 temp. variation

Heat storage capacity: Heat capacity of the entire component: 438 kJ / m² K or 0.12 kWh / m² K (KJ energy in kWh and that receives one of the square member when indoor and outdoor temperature by 1 ° C at the same time can be increased.)

Heat storage capacity of the internal layers: 111 kJ / m² K or 0,031 kWh / m² K (KJ energy in kWh and that receives a square meter of the component, when the inner temperature is increased by 1 ° C and Outside temperature is maintained.)

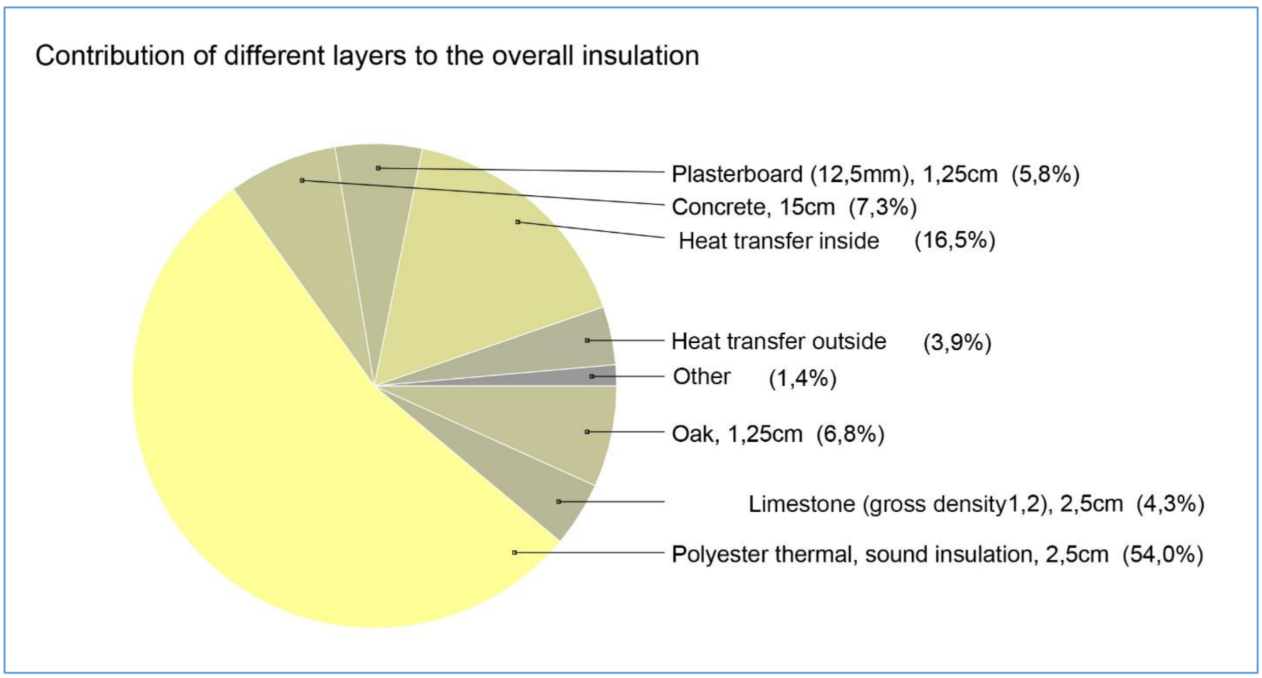


Figure 217 layers insulation effect

Thermal Bridge: Heat will flow the easiest path from the heated space to the outside - the path with the least resistance. And this will not necessarily be the path perpendicular to the surfaces. Very often heat will "short circuit" through an element which has a much higher conductivity than surrounding material. In such cases the experts call this a "thermal bridge".

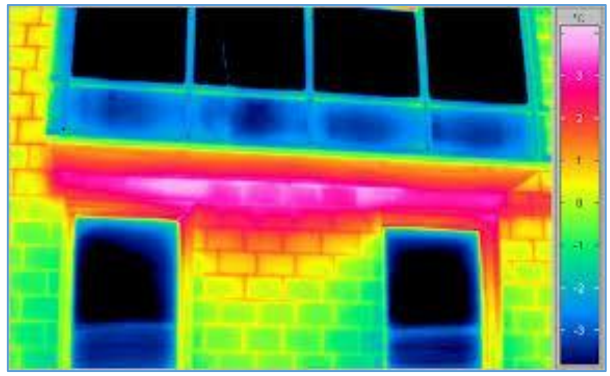


Figure 218 joints, critical points of thermal bridge

as for the architecture of our project, the concrete slabs that come out of the lateral parts of the building, and make the shading for large fenestration, are in risk of producing a strong point of thermal bridge. [88]

In a Passive home the heat losses of thermal bridges are significantly reduced, too. The reduction is made to a degree that the losses through thermal bridges become negligible. If the thermal insulation is not disturbed at any place of the envelope, the heat loss calculated with the U-values and the external surface areas of the building will be higher than the actual losses (including all thermal bridges).

if we consider a continuous and constant layer of insulation and covers the outer side of the façade, we could prevent possible thermal bridges. But as the extended slabs will cuts such a layer on insulation and make into segments, it may cause the thermal bridges. To deal with the issue, we used special blocks of insulation. For such a reason we have employed Isokorb blocks which are placed in the concrete in time of casting. Its reinforced bars are placed along with the bars of concrete slab, and make in fact an integrated part of the slab.

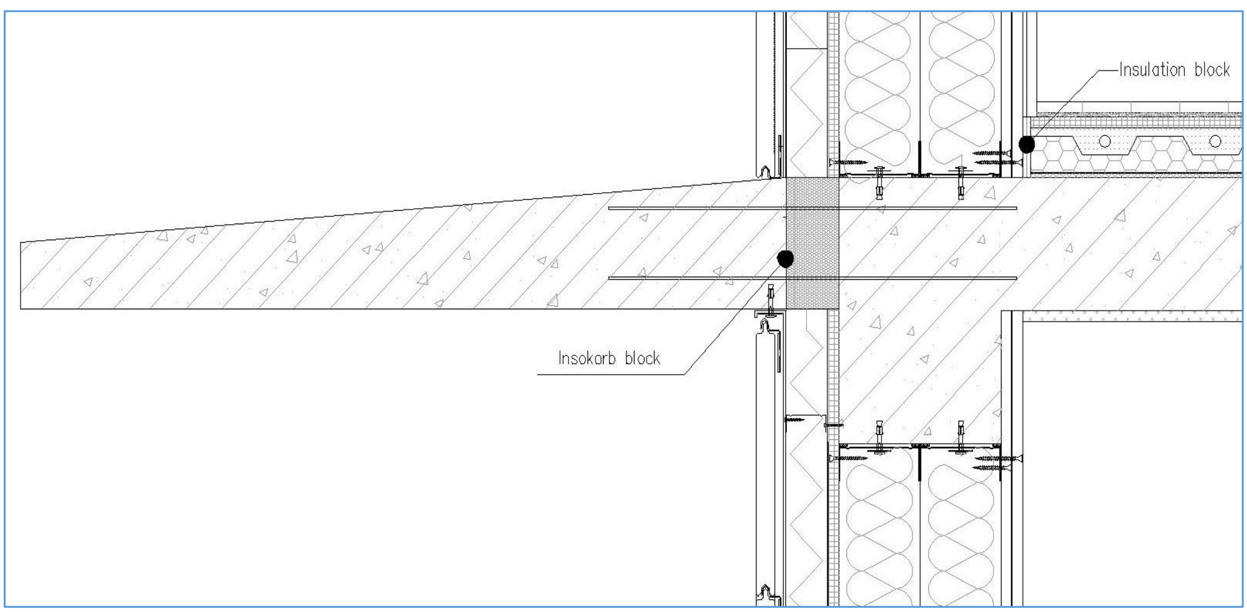
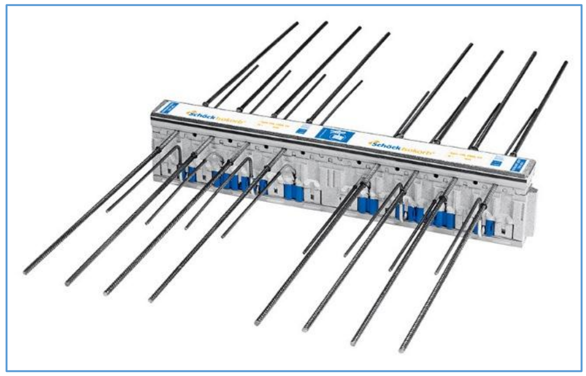
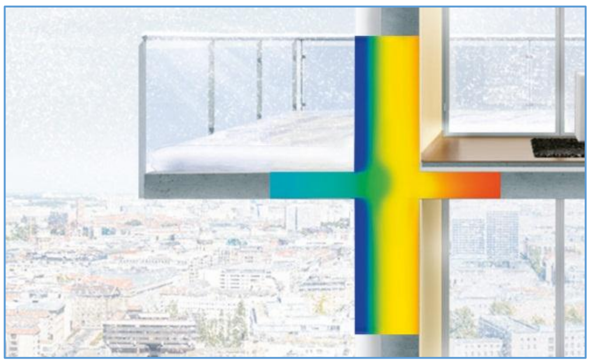


Figure 219 detail of building joints

[88] http://www.passivhaustagung.de

The **Schöck Isokorb® type CM** is a load bearing thermal insulation element for cantilever concrete slabs such as balconies. The element transfers bending moment stress and shear forces. The integrated hanging and perimeter tensile reinforcement, fitted as standard, saves the unnecessary and costly use of extra stirrups or hooped mat.





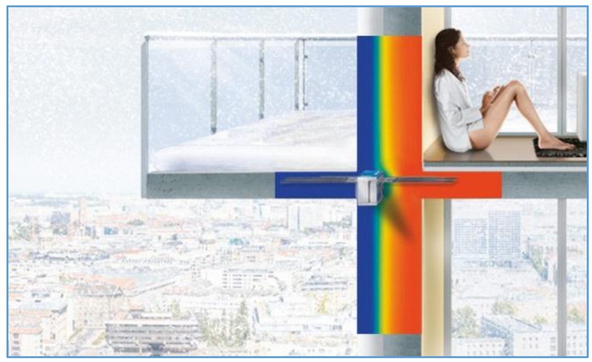
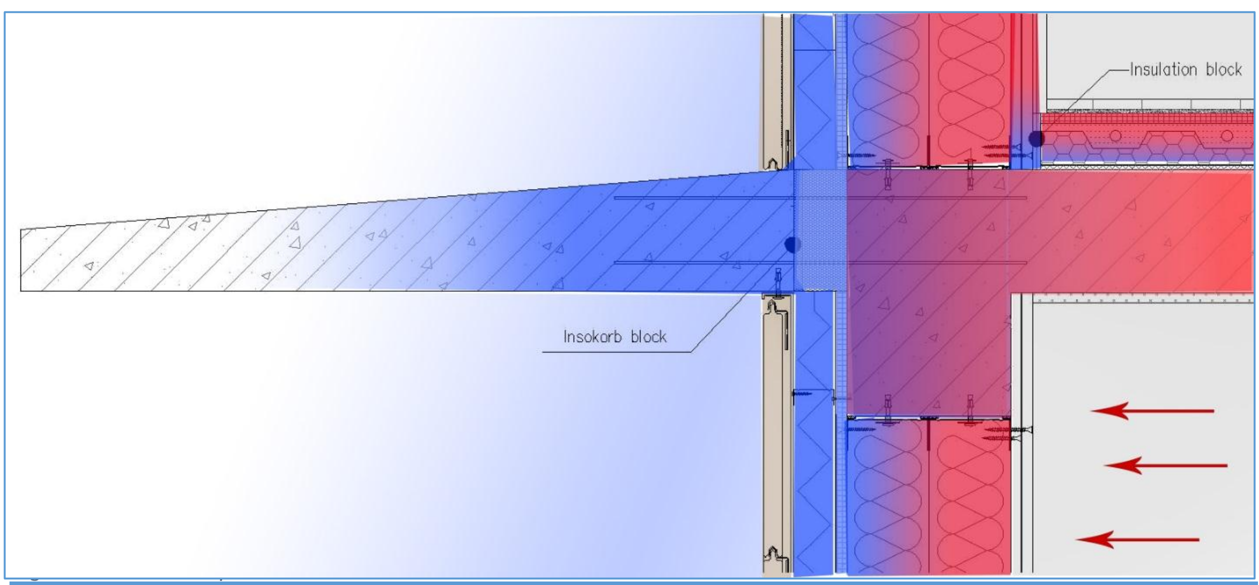


Figure 220 Above: IsoKorp CM Left : thermal bridge without isokorp Right: Thermal bridge stop with use of Isokorp

Above in the figures we can see the effect of stopping thermal bridges at the joint of the balcony. Below we have stimulated the function on this important joint of building. The lighter hot air can get transferred through the slabs where the last layer of insulation stops them.



4.8 Thermal Analysis:

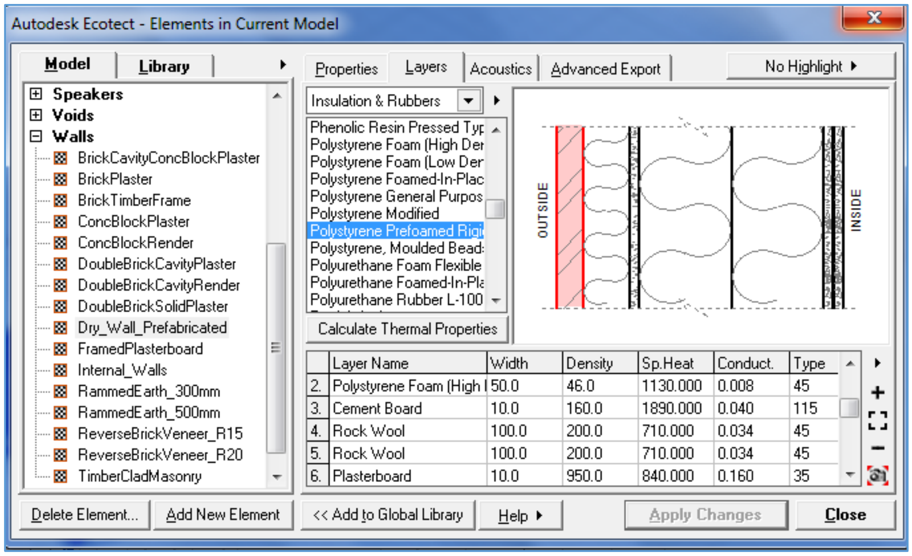
The heating load is the amount of heat energy that would need to be added to a space to maintain the temperature in an acceptable range. The cooling load is the amount of heat energy that would need to be removed from a space (cooling) to maintain the temperature in an acceptable range.
The heating and cooling loads, or "thermal loads", take into account:
-the dwelling's construction and insulation; including floors, walls, ceilings and roof; and
-the dwelling's glazing and skylights; based on size, performance, shading and overshadowing.
Thermal analysis basically means using a manual calculation or computer program to mathematically model the interplay of thermal processes within a building. There are a wide range of mathematical models used for this purpose, all of which vary significantly in both ease of implementation and comprehensiveness.
As for solar analysis, we choose unit 1 to perform this analysis on using Ecotect. With correct information given into the program, such as wall thermal performance of the walls and usage of the spaces, we can have an idea of the energy consumption level of the building.
As part of ongoing research into automated compliance testing of building models against building regulations, the first set to have been fully implemented in Ecotect is Part-L of the UK Building Regulations, detailing guidelines for the conservation of fuel and power. UK Part-L:
The Conservation of Fuel and Power: Part L deals with the conservation of fuel and power in buildings throughout the UK. It is part of a broad wave of European legislation which seeks to encourage industry-wide adoption of energy efficient practices and waste minimisation techniques. This legislation is only in its infancy, however it is already having a significant impact on the local building industry.
In terms of Part-L (Part-J in Scotland), Ecotect is the only building modelling and analysis tool to directly address all aspects of compliance, including the Elemental Method. Obviously the Whole Building Methods for Schools and Hospitals are dictated by Education and NHS guidelines, however the Carbon Performance Rating (CPR) for office buildings is supported

the procedure of working with ecotect upon completion of model, is to choose the right materials for different building elemnts, check to import the correct information about the properties of materials such as U-Value, define the usage of spaces, hours of use and conditioning situation of the spaces. Give all these data, Ecotect also takes into account the invironmental aspects of the project such as sun and wind, to determine heat gains and losts and finally we can have different diagrams, and numeric information about heating and cooling loads and the related data.

4.8.1 Ecotect Model properties :

-Properties of external walls:

We chose the layers used for our external walls and after Ecotect calculated its thermal properties, as seen in the figure above. The information tells us of a good thermal performance for this external wall.

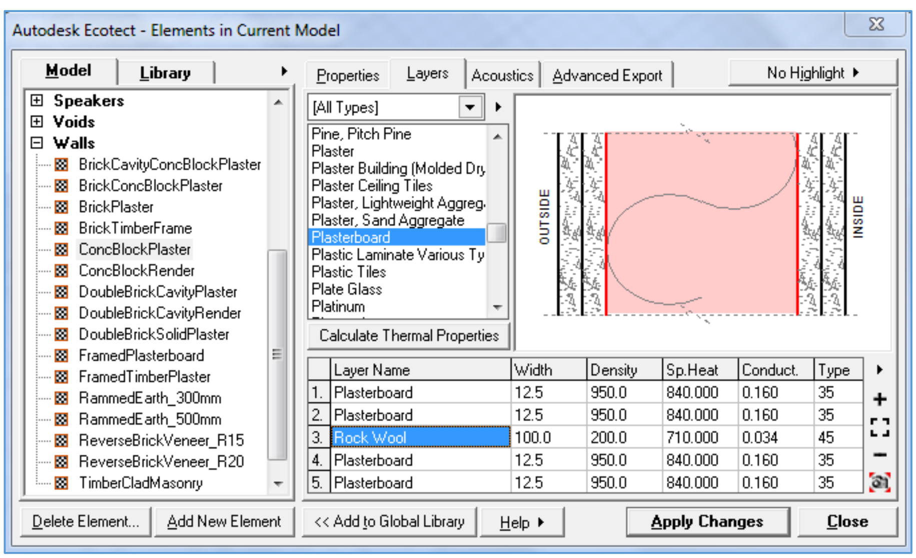


U-Value (W/m2.K):	0.137
Admittance (W/m2.K):	1.590
Solar Absorption (0-1):	0.7
Visible Transmittance (0-1):	0
Thermal Decrement (0-1):	0.18
Thermal Lag (hrs):	7.7
[SBEM] CM 1:	0
[SBEM] CM 2:	0
Thickness (mm):	311.0
Weight (kg):	168.000

Figure 222 Ecotect material window

-Properties of internal walls:

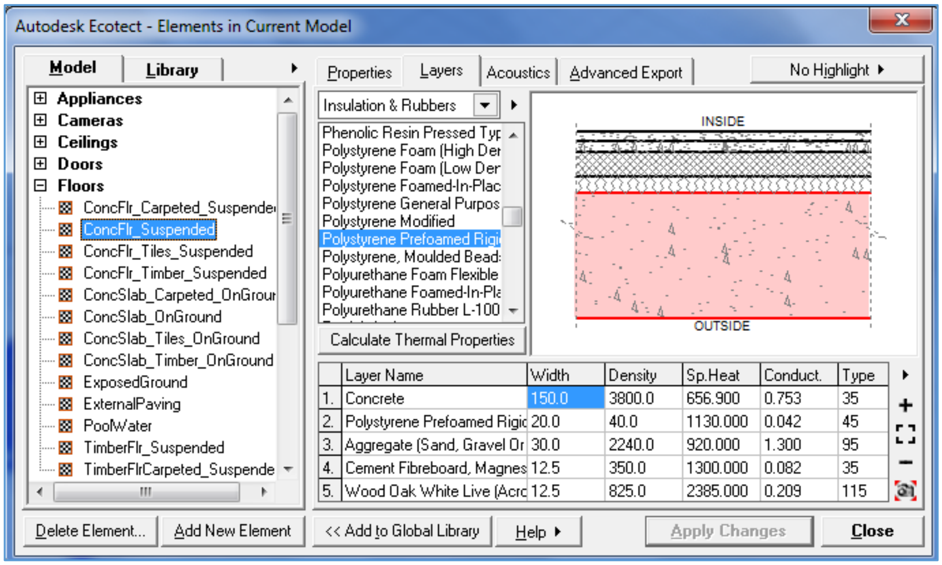
Also here we have imported a simplified version of the internal walls in the ecotect material dualauge box.



U-Value (W/m2.K):	0.31
Admittance (W/m2.K):	1.600
Solar Absorption (0-1):	0.506
Visible Transmittance (0-1):	0
Thermal Decrement (0-1):	0.86
Thermal Lag (hrs):	5
[SBEM] CM 1:	0
[SBEM] CM 2:	0
Thickness (mm):	150.0
Weight (kg):	49

-Properties of general floors:

Properties of floors and ceilings have been considered the same, as for this unit that is in the middle floor between 1 floor above and below it.



U-Value (W/m2.K):	0.970
Admittance (W/m2.K):	3.060
Solar Absorption (0-1):	0.322353
Visible Transmittance (0-1):	0
Thermal Decrement (0-1):	0.2
Thermal Lag (hrs):	4
[SBEM] CM 1:	0
[SBEM] CM 2:	0
Thickness (mm):	225.0
Weight (kg):	438.000

-Properties of Spaces:

In ecotect different spaces are identified as zones. The internal walls determine the borders of these zones. The zone properties are important for calculating heating and cooling loads. These properties include occupation of different spaces, kind of function, number of occupants, air conditioning system, air exchange rate and other factors.

The zones are diviede to :

-3 Bedrooms -Service Zone -Kitchen and living room

Considerations:

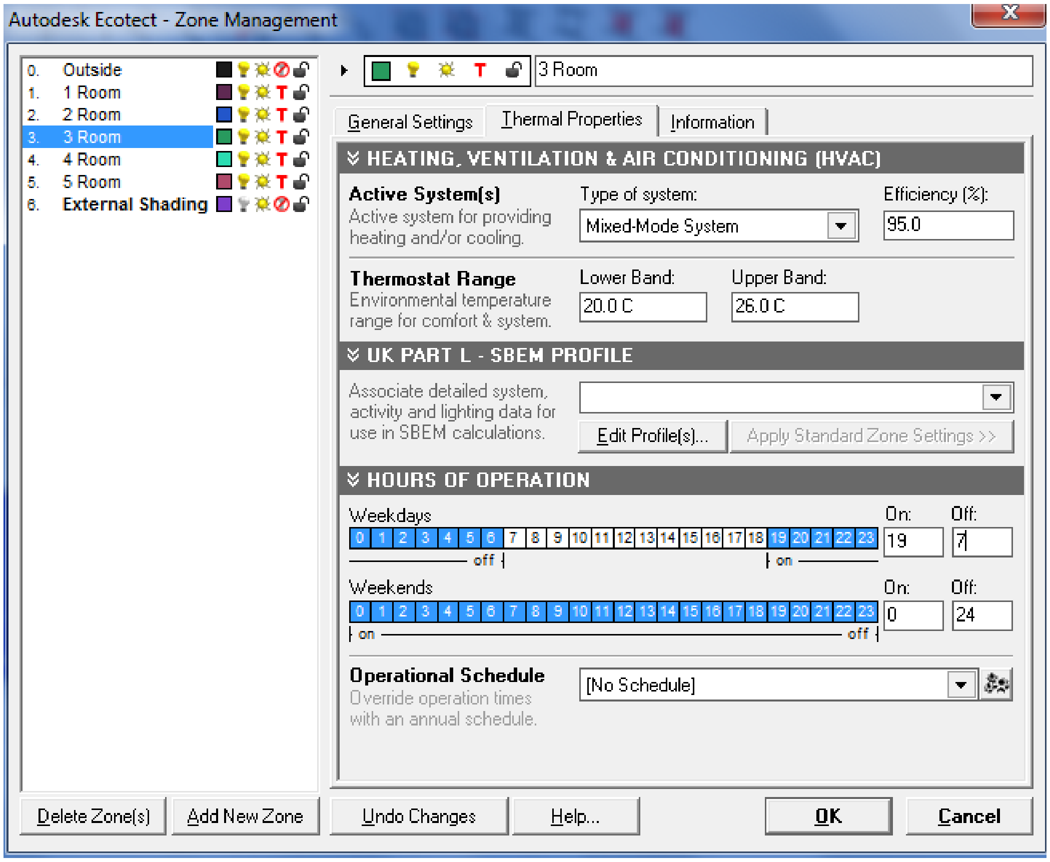
- Design for mixed mode system
- Thermostat range: 20 °C to 26 °C
- Operating hours:

19 pm to 08 am on weekdays, 24/24h on weekends for this residential unit

Why mixed mode system?

As we are using mixed mode system with thermostat range 20-26 °C which means some time we can use mechanical ventilation to maintain this range & sometimes we can use natural ventilation when outdoor temperature & humidity is in an acceptable range.

we had to consider the service zone with less conditioning needs and thus we reduced the ours of its use to very minimum.



4.6.2.1 Monthly load discomfort analysis for unit 1

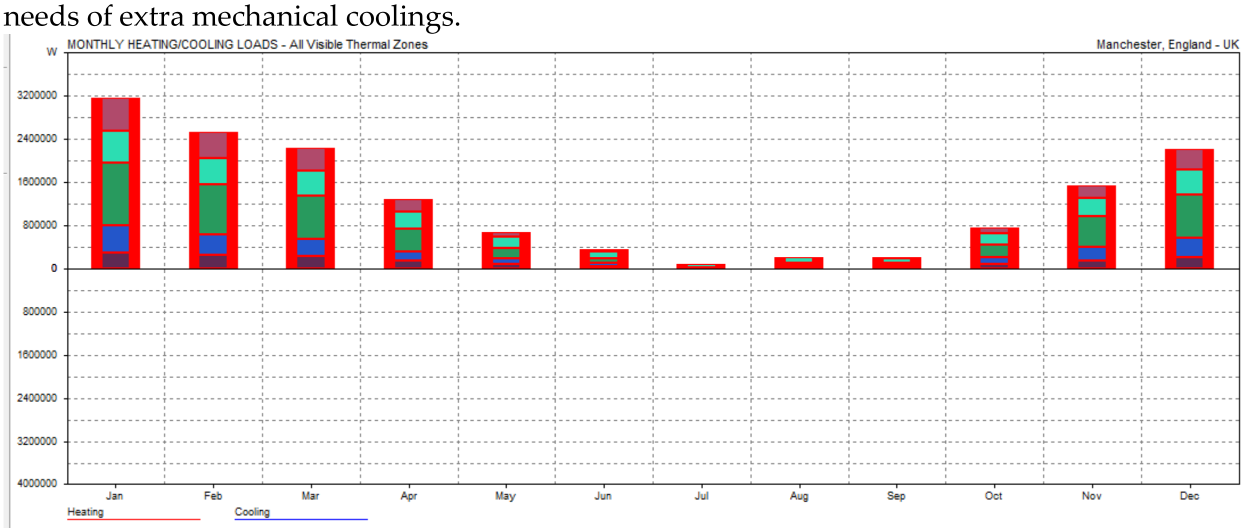
So after importing the related data we can see perform the thermal analysis calculation and achieve different result. Here we present the heat and cooling loads:, these information bellow show the properties of zones ready to be analyzed.

ZONE SUMMARY

Zone Name	Floor (m2)	Areas Surface (m2)	Exposed (m2)	Window (m2)	Volume (m3)	HVAC System	Temp. Range	Operation Hours
BED Room 1	42.144	102.849	72.910	10.490	69.712	Mixed Mode	18.0-26.0	18-07/10-03
BED ROOM 2	45.895	109.385	77.349	20.279	76.261	Mixed Mode	18.0-26.0	09-24/12-24
KITCHEN -LIVING	167.543	297.742	256.167	20.707	279.391	Mixed Mode	18.0-26.0	09-24/12-24
Master Bedroom	66.885	146.593	89.713	15.215	110.868	Mixed Mode	20.0-26.0	18-06/00-24
Service Zone	108.990	224.695	152.742	1.859	179.824	Mixed Mode	18.0-26.0	04-24/03-24
External Shading	0.000	2674.667	2674.667	0.000	0.000	Non-Thermal	--	--
TOTAL	431.457	881.265	648.880	68.550	716.056			

All Visible Thermal Zones			
Comfort: Zonal Bands			
Max Heating: 11287 W at 21:00 on 10th February			
Max Cooling: 0.0 C - No Cooling.			
	HEATING	**COOLING**	**TOTAL**
MONTH	**(Wh)**	**(Wh)**	**(Wh)**
Jan	3157576	0	3157576
Feb	2538481	0	2538481
Mar	2241488	0	2241488
Apr	1279266	0	1279266
May	678718	0	678718
Jun	355463	0	355463
Jul	80105	0	80105
Aug	215860	0	215860
Sep	200817	0	200817
Oct	754804	0	754804
Nov	1549922	0	1549922
Dec	2211881	0	2211881
TOTAL	**15264381**	**0**	**15264381**
PER M²	**35379**	**0**	**35379**
Floor Area:	**431.457 m2**		

The result is a heating load of 35379 Wh during a year per square meter. We don’t see any any needs of extra mechanical coolings.



-Different zones: Here we break down the thermal analysis above, into each zone.
In this way we can compare the effect of location and unction of different spaces on their heating loads.

BedRoom1 and 2:

MONTHLY HEATING/COOLING LOADS

Zone: 1 Room				Zone: 2 Room			
Operation: Weekdays 18-07, Weekends 10-03.				Operation: Weekdays 09-24, Weekends 12-24.			
Thermostat Settings: 18.0 - 26.0 C				Thermostat Settings: 18.0 - 26.0 C			
Max Heating: 1110 W at 01:00 on 11th February				Max Heating: 2013 W at 21:00 on 10th February			
Max Cooling: 0.0 C - No Cooling.				Max Cooling: 0.0 C - No Cooling.			
	HEATING	COOLING	TOTAL		HEATING	COOLING	TOTAL
MONTH	(Wh)	(Wh)	(Wh)	MONTH	(Wh)	(Wh)	(Wh)
Jan	306995	0	306995	Jan	509464	0	509464
Feb	256136	0	256136	Feb	396383	0	396383
Mar	235255	0	235255	Mar	338028	0	338028
Apr	144307	0	144307	Apr	183356	0	183356
May	89211	0	89211	May	99197	0	99197
Jun	53060	0	53060	Jun	49973	0	49973
Jul	10364	0	10364	Jul	11460	0	11460
Aug	27224	0	27224	Aug	36336	0	36336
Sep	25807	0	25807	Sep	33555	0	33555
Oct	87318	0	87318	Oct	125396	0	125396
Nov	149787	0	149787	Nov	265193	0	265193
Dec	216897	0	216897	Dec	364639	0	364639
TOTAL	**1602362**	**0**	**1602362**	**TOTAL**	**2412979**	**0**	**2412979**
PER M²	**38021**	**0**	**38021**	**PER M²**	**52577**	**0**	**52577**
Floor Area:	**42.144 m2**			**Floor Area:**	**45.895 m2**		

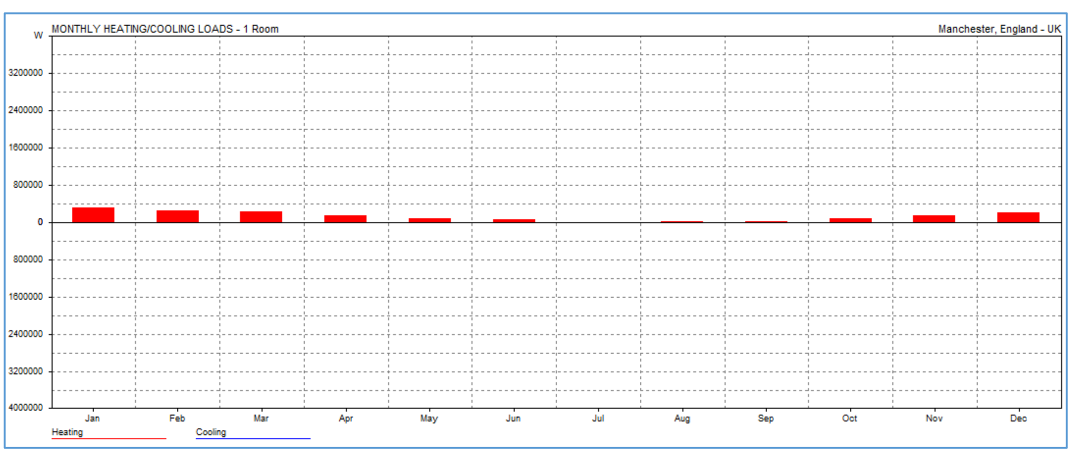


Figure 223 B.R 1 Thermal analysis

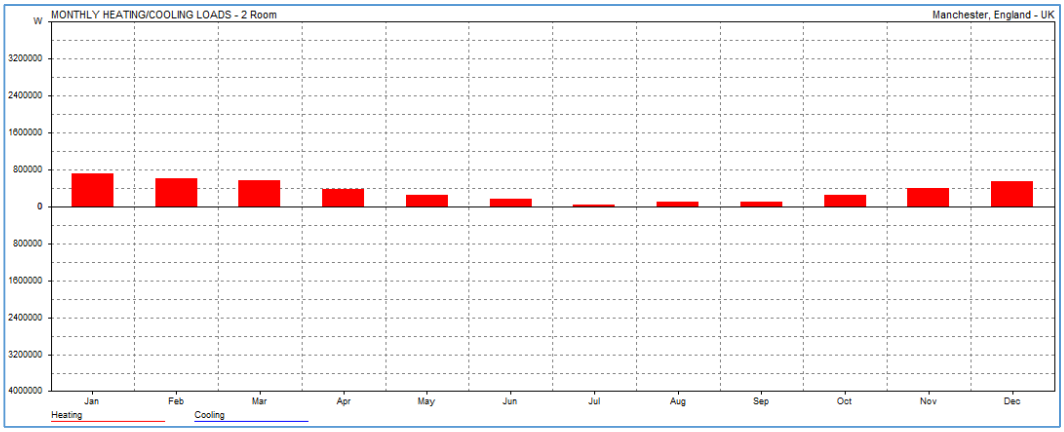


Figure 224 B.R 2 Thermal Analysis

Figure 225 B.R 1 and 2 Location

As seen from the graphs and information above, room 1 has a heating load of 38021 Wh while the room 2 takes the amount up to 52577 Wh. Though room 2, the one in corner as marked in the figure, has more fenestration and can receive more sun, but as the U-value of windows are about 2 and the walls about .137 W/m2K which causes larger amounts of heat loss.

Kitchen and living:

Zone: 3 Room			
Operation: Weekdays 09-24, Weekends 12-24			
Thermostat Settings: 18.0 - 26.0 C			
Max Heating: 4968 W at 16:00 on 10th Februa			
Max Cooling: 0.0 C - No Cooling.			
	HEATING	COOLING	TOTAL
MONTH	(Wh)	(Wh)	(Wh)
Jan	1205300	0	1205300
Feb	950415	0	950415
Mar	818286	0	818286
Apr	437679	0	437679
May	203047	0	203047
Jun	83264	0	83264
Jul	7760	0	7760
Aug	45573	0	45573
Sep	45484	0	45484
Oct	251037	0	251037
Nov	595642	0	595642
Dec	838465	0	838465
TOTAL	5481952	0	5481952
PER M²	32720	0	32720
Floor Area:	167.543 m2		

This is the largest zone in terms of area, as highlightd in red in the figure below. This is in face the most energy consuming zone.

Figure 226 Kitchen and Living Analysis

Service Zone:

Zone: Service Zone			
Operation: Weekdays 04-12, Weekends 04-12.			
Thermostat Settings: 18.0 - 22.0 C			
Max Heating: 1803 W at 08:00 on 12th February			
Max Cooling: 923 W at 12:00 on 4th July			
	HEATING	COOLING	TOTAL
MONTH	(Wh)	(Wh)	(Wh)
Jan	266181	0	266181
Feb	213427	0	213427
Mar	197350	0	197350
Apr	103108	0	103108
May	47707	0	47707
Jun	17521	0	17521
Jul	911	1778	2689
Aug	3059	0	3059
Sep	5615	0	5615
Oct	46496	0	46496
Nov	108698	0	108698
Dec	167318	0	167318
TOTAL	**1177391**	**1778**	**1179169**
PER M²	**10803**	**16**	**10819**
Floor Area:	**108.990 m2**		

The operation time of this spaces are limited and also the max heating has been considered 22. As we see these two factors make the zone the least energy concumer.

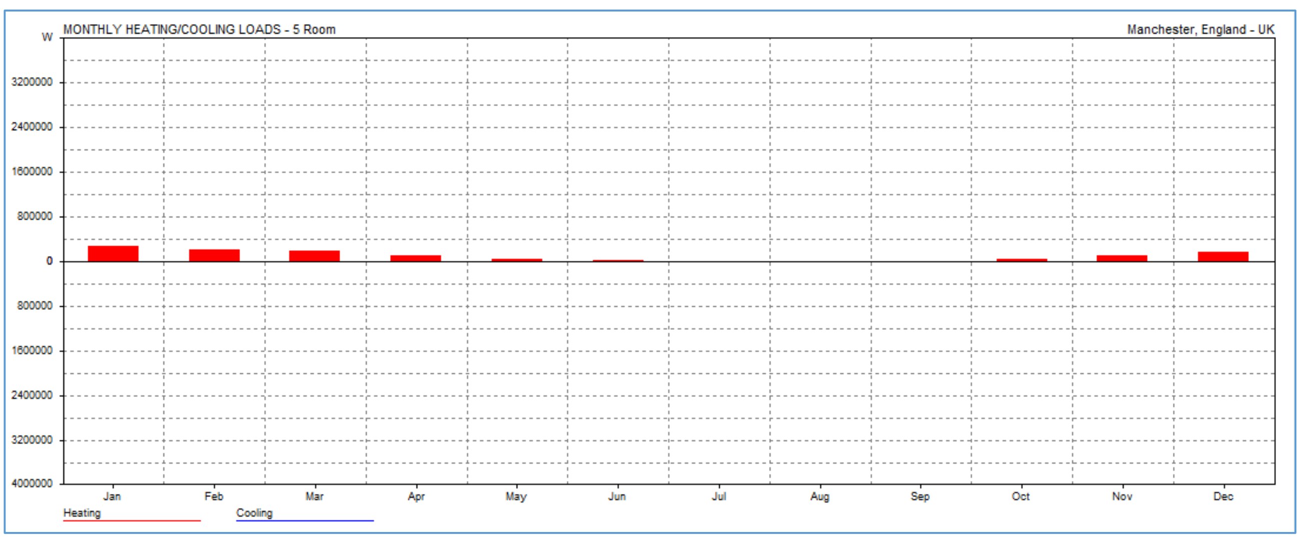


Figure 227 Servie Zone Thermal Analysis

We have a number of more analysis and information about thermal conditions of the building. In the figure below we see the breakdown of passive gains in our building. As seen the contribution of solar gains and heat conduction on the envelope are the more important sources of heat gain while heat lost through conduction and air ventilation as considerable.

GAINS BREAKDOWN - All Visible Thermal Zones
FROM: 1st January to 31st December

CATEGORY	LOSSES	GAINS
------------	-------	------
FABRIC	49.0%	0.0%
SOL-AIR	0.0%	2.9%
SOLAR	0.0%	27.9%
VENTILATION	50.9%	0.1%
INTERNAL	0.0%	68.8%
INTE	0.3%	

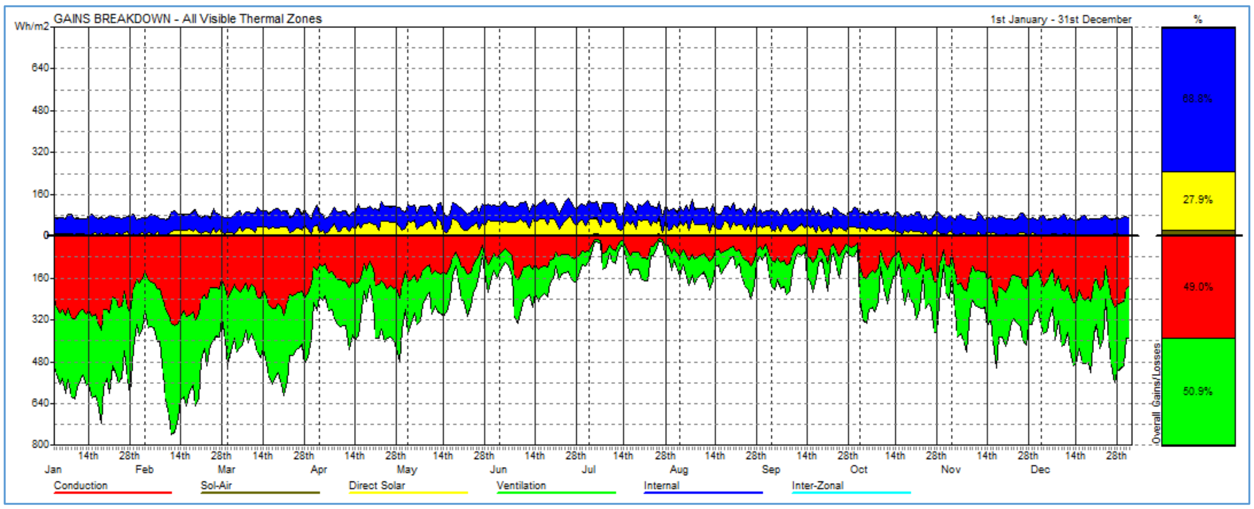
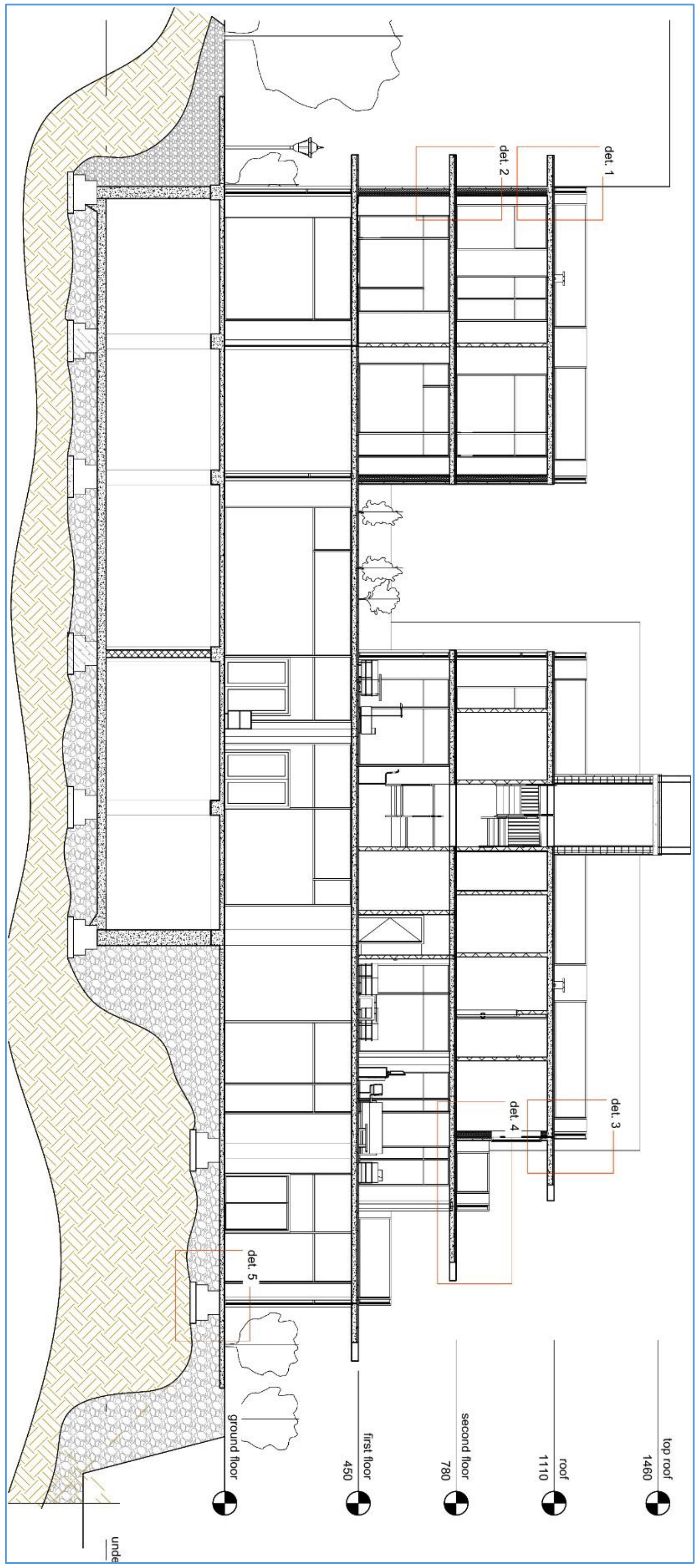


Figure 228 heat gain and loss

4.9 Details

in the detailed section presented here some important parts are further detailed and presented in a larger scale following.



4.9.1 Detail 1

1---------------------------------

Vegetation
Growing medium 100mm
System filter membrane 1mm
Drainage element/reservoir and root barrier 30mm
Polyfoam slimline menbrane 1mm
Extruded polystyrene board 110mm
Waterfroofing layer 1mm
Plasterboard 12.5mm
Screed laid to falls 40mm
Reinforced concrete roof deck 150mm
Plasterboard 12.5mm

2---------------------------------

Fiber cement board 10mm
Render 10mm
Plasterboard 12.5mm
Vapor barrier (aluminum foil) 1mm
Extruded polystyrene board 25mm
Reinforced concrete 150mm
Extruded polystyrene board 62mm
Render 10mm

3---------------------------------

Plasterboard 12.5mm
Vapor barrier (aluminum foil) 1mm
Plasterboard 12.5mm
Insulation (rock wool) 100mm
Insulation (rock wool) 100mm
Fiber cement board 10mm
Adhesive layer 2mm
Extruded polystyrene board 50mm
Metal Subtructure 3 mm
Stone cladding 30 mm

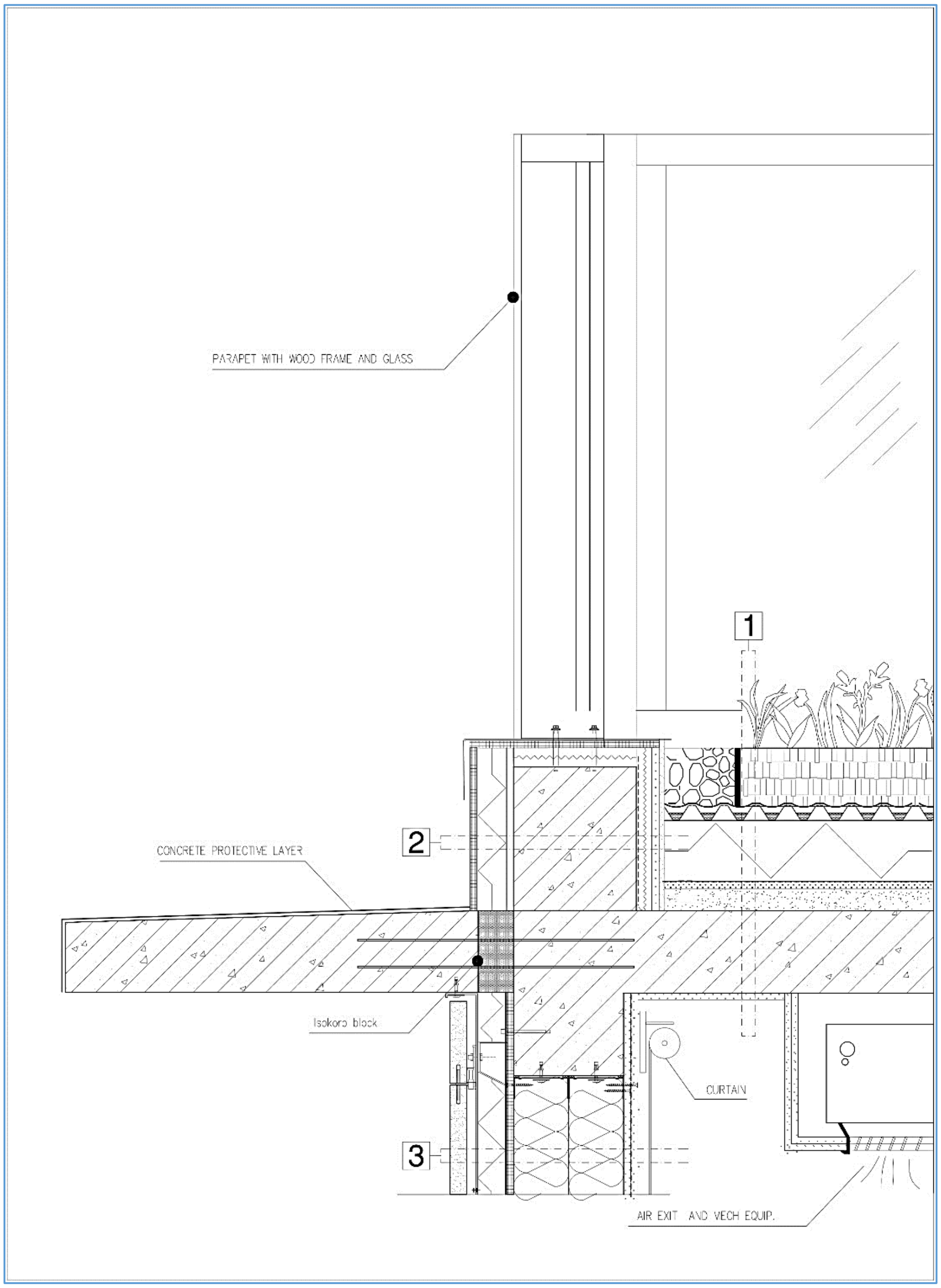
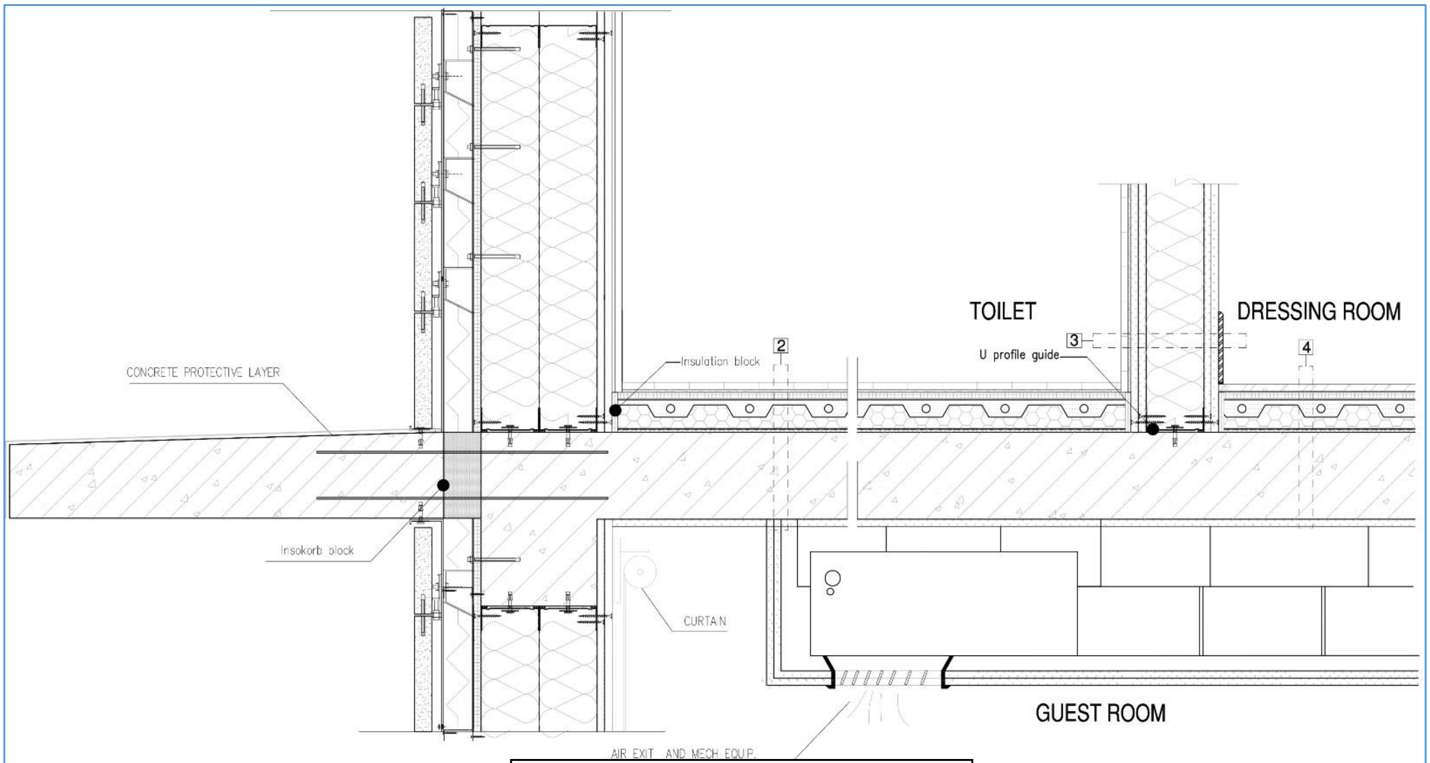


Figure 229 Det.1

4.9.2 Detail 2 (Case of Bathroom)



1-------------------- -------

Ceramic tiles 12.5mm
Tile mortar 5mm
Moistureshield plasterboard 12.5mm
Vapor barrier (aluminum foil) 1mm
Plasterboard 12.5mm
Insulation (rock wool) 100mm
Insulation (rock wool) 100mm
Fiber cement board 10mm
Adhesive layer 2mm
Extruded polystyrene board 50mm
Render 5mm

2------------

Ceramic tiles 12.5mm
Tile mortar 5mm
Fiber cement board 12.5mm
Sand layer w/heating inserts 30mm
Polystyrene insulation layer 20mm
Polyethylene vapor barrier 1mm
Acoustical lining 5mm
Concrete slab 100mm
Plasterboard 12.5mm

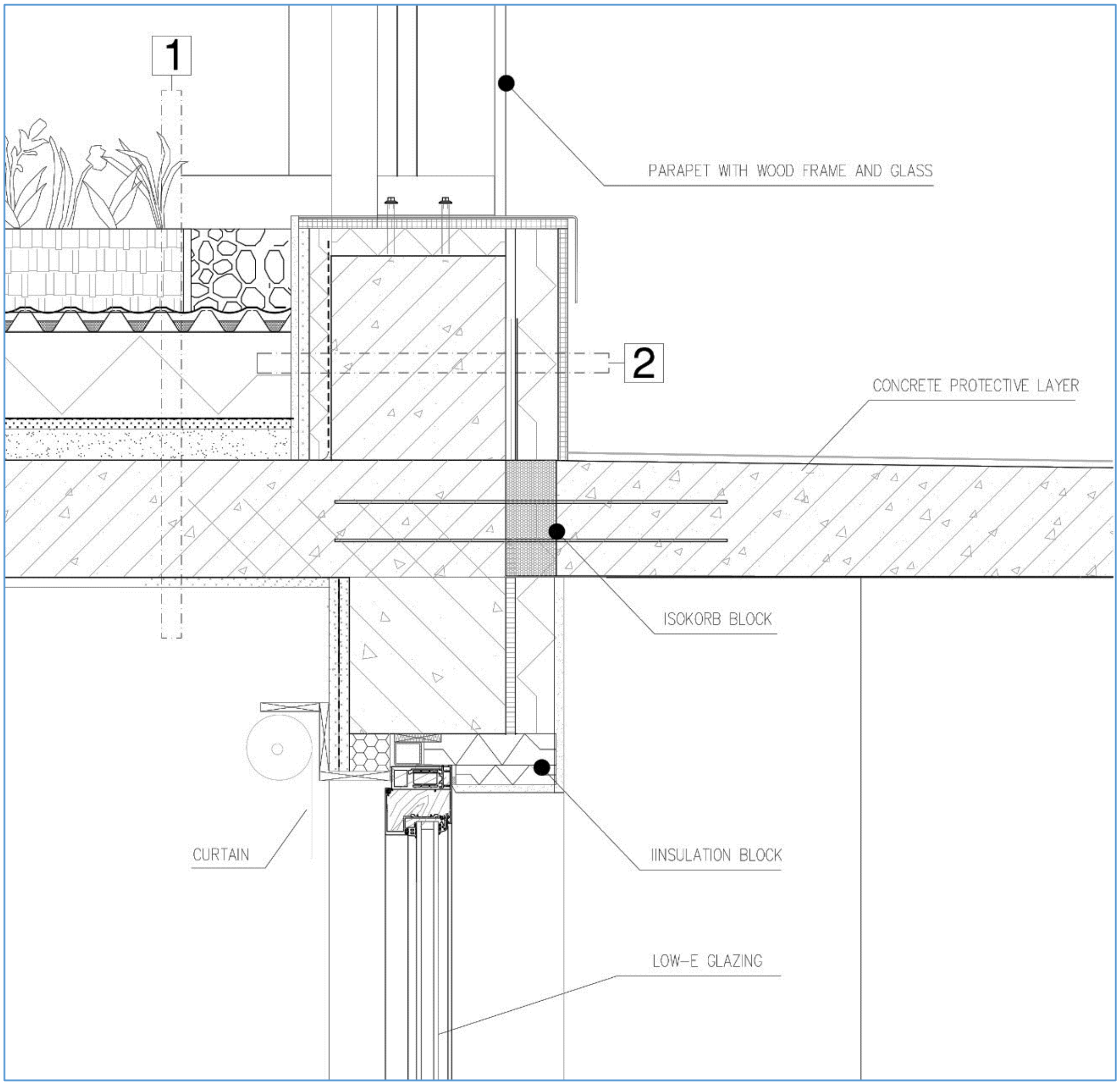
3--------

Ceramic tiles 12.5mm
Tile mortar 5mm
Moisture shield plasterboard 12.5mm
Vapor barrier 1mm
Plasterboard 12.5mm
Insulation (rock wool) 100mm
Double layer plasterboard 25mm
Baseboard 2.5mmx120mm

4--------------------------

Parquet floor 12.5mm
Adhensive layer 2mm
Fiber cement board 12.5mm
Sand layer w/heating inserts 30mm
Polystyrene insulation layer 20mm
Polyethylene vapor barrier 1mm
Acoustical lining 5mm
Concrete slab 100mm
Plasterboard 12.5mm

4.9.3 Detail 3 - Window Joint Detail

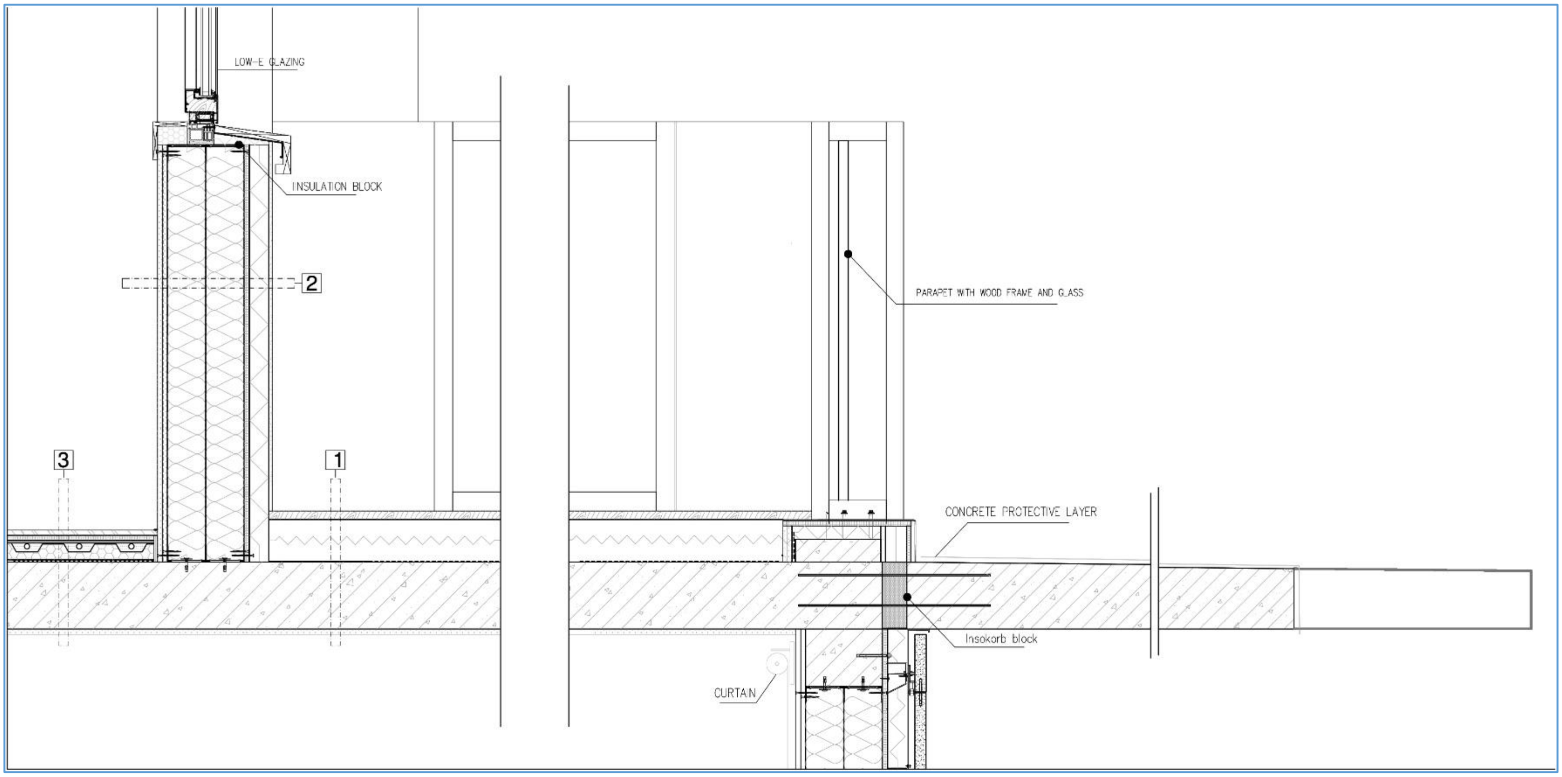


1---------------------------------------
Vegetation
Growing medium 100mm
System filter membrane 1mm
Drainage element/reservoir and root barrier 30mm
Polyfoam slimline menbrane 1mm
Extruded polystyrene board 110mm
Waterfroofing layer 1mm
Plasterboard 12.5mm
Screed laid to falls 40mm
Reinforced concrete roof deck 150mm
Plasterboard 12.5mm

2----------------------------------

Polyfoam slimline membrane 1mm
Fiber cement board 10mm
Extruded polystyrene board 25mm
Vapor barrier (aluminum foil) 1mm
Concrete 150mm
Extruded polystyrene board 62mm
Render 10mm

4.9.4 Detail 4 – Balcony Detail



1----------------

Timber deck panals 21mm
Polyfoam slimline membrane 1mm
Extruded ploystyrene board 110mm
Waterproofing layer 1mm
Concrete slab 100mm
Plasterboard 12.5mm

2----------------

Plasterboard 12.5mm
Vapor barrier (aluminum foil) 1mm
Plasterboard 12.5mm
Insulation (rock wool) 100mm
Insulation (rock wool) 100mm
Fiber cement board 10mm
Adhesive layer 2mm
Extruded polystyrene board 50mm
Metal Subtructure 3 mm
Stone cladding 30 mm

3----------------

Parquette 12.5mm
Adhesive layer 5mm
Fiber cement board 12.5mm
Sand layer w/heating inserts 30mm
Polystyrene insulation layer 20mm
Polyethylene vapor barrier 1mm
Acoustical lining 5mm
Concrete slab 100mm
Plasterboard 12.5mm

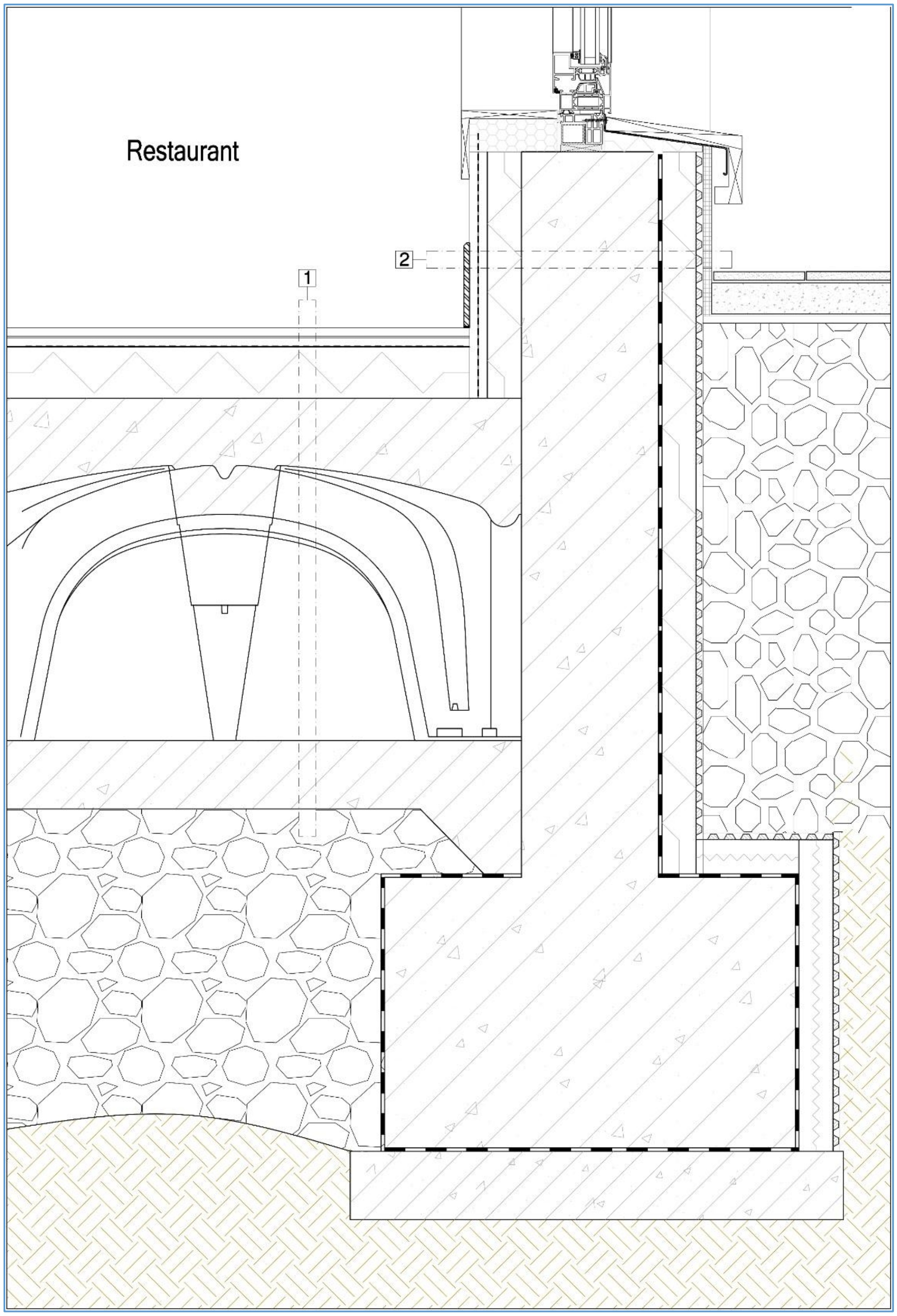
4.9.5 **Detail 5** – Ground Floor Base

1------------------

Parquet floor 12.5mm
Adhensive layer 2mm
Fiber cement board 12.5m
Vapor barrier 1mm
Extruded polystyrene board 75mm
Concrete 100mm
Recyecled polypropyle unit 400mm
Concrete 100mm

2------------------

Baseboard 2.5mmx120mm
Plasterboard 12.5mm
Vapor barrier (aluminum foil) 1mm
Plasterboard 12.5mm
Extruded polystyrene board 50mm
Reinforced concrete 200mm
Waterproofing membrane 5mm
Extruded polystyrene board 50mm
Cavity drainage membrane 10mm



STRUCTURAL DESIGN

chapter 5

MASTER OF ARCHITECTURAL ENGINEERING – THESIS REPORT

Chapter 5 - Structure

5.1 Introduction:

In this chapter, the design process for the structure is explained from the beginning to the final results of the design for the columns and beams, using the related Codes and the structural design software called Etabs.
As we have discussed in the previous chapters, the structure plays an important role in our design, not only as the structure of the building , but the slab cantilevers play an important role also as an important architectural element, and as the shading, as part of our environmental consideration in technological design phase.
To examine the feasibility of our architectural and technological design to be constructed, and to determine the dimensions of beams and columns, the following processes where necessary to obtain data from structural analysis.

5.2Configuration of the software:

The building is one part of the whole design of the site, which consists of three separated buildings. It is a three-story building mainly residential with a green roof. After careful architectural considerations the column are placed as following with spans less than 6 meters to make it more reliable and economical in structural point of view.

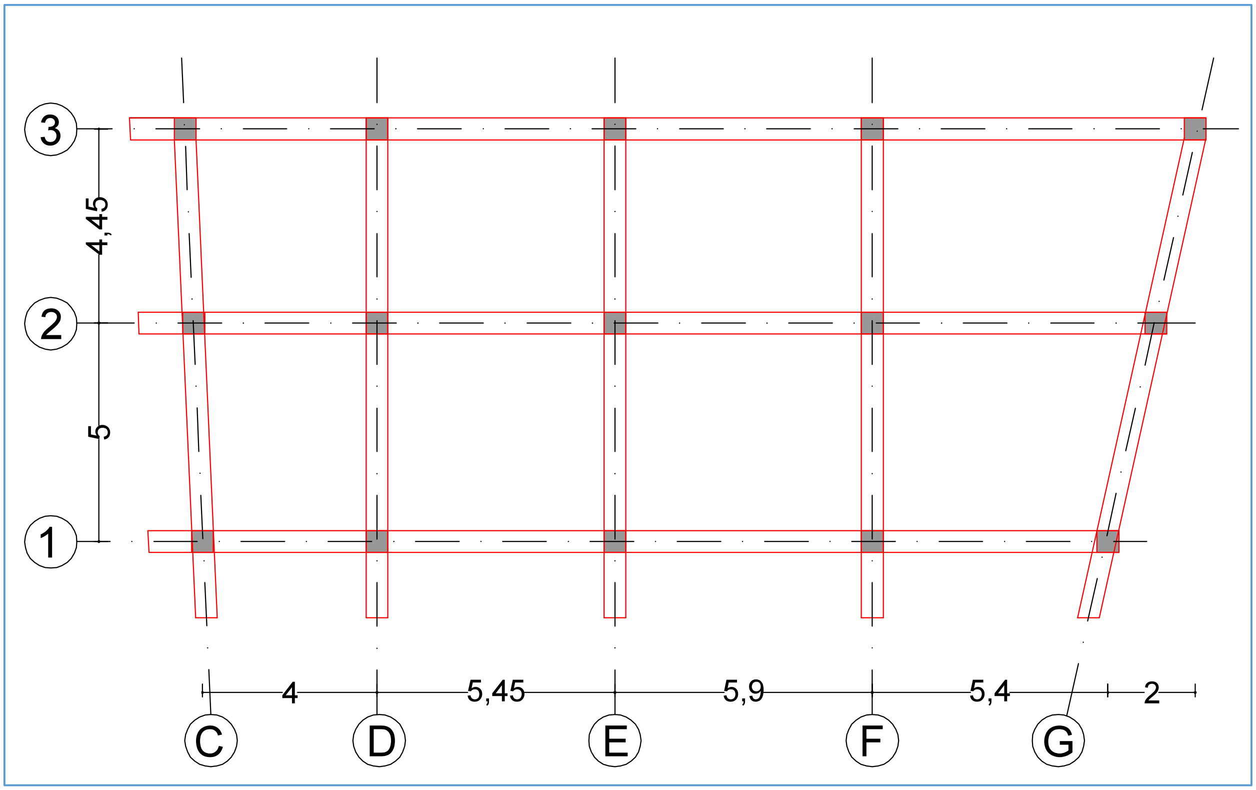


Figure 230 spans distances

The structure we are using is reinforced concrete fixed-frame structure. The concrete designed for the structure has the characteristics below.

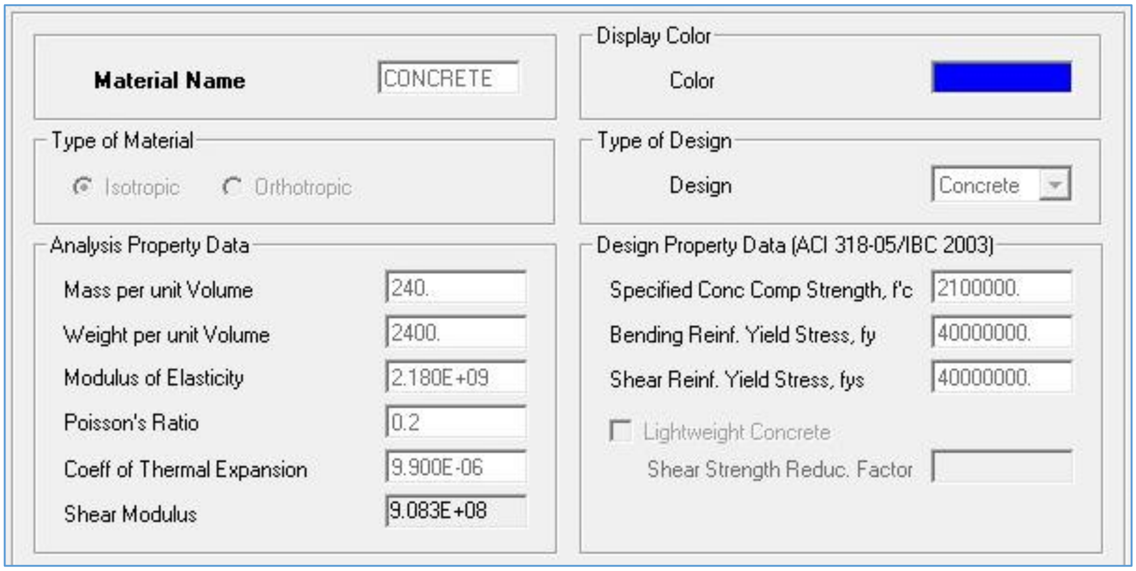


Figure 231 concrete characteristics

Considering the standards related to loading, we have 7 different load cases for our design, which gives us different load combination according to the standards in the software.

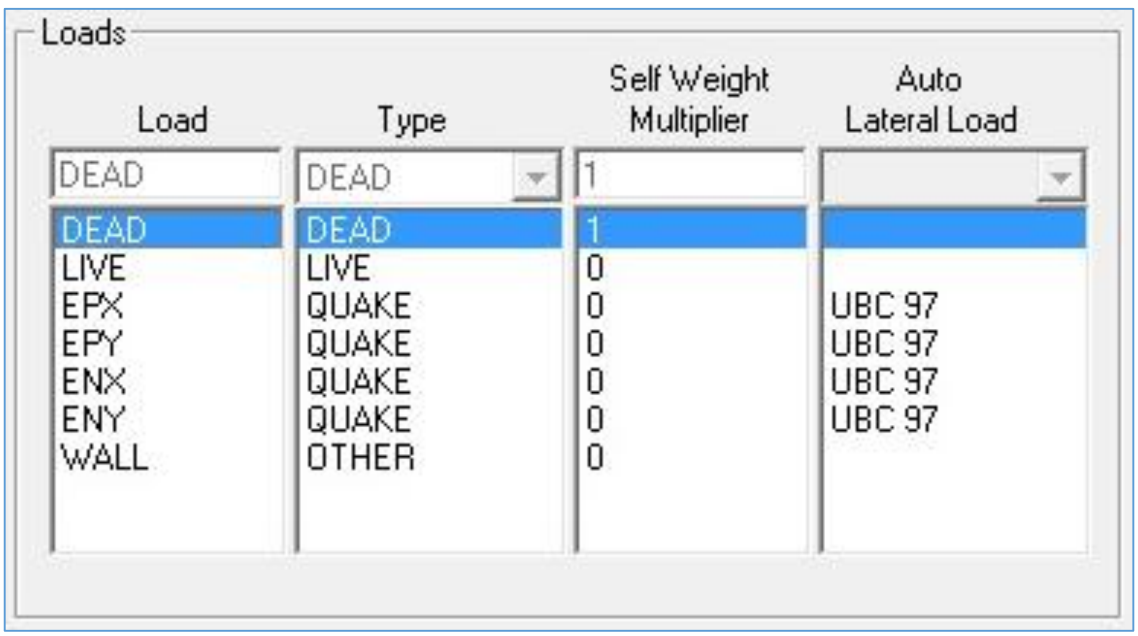


Figure 232 Load cases

5.3 Design process:

The design process in ETABS is a try and error process, in which we start by giving assumptions for the size of the columns and the reinforcements inside, then the size of the beams are given to the software. The software analyzes the structure according to the loads and the load cases given to the structure before and gives us the structural analysis. After the first analysis we change the sections for the columns to have the most efficient design according to the capacity ratio given by the software, it also helps us not to overdesign the structure. Choosing the sections of the columns, we start the design of the reinforcements for the beams with the previously designed sizes. Finally the sections are being checked to have the concrete covers inside and on the sides in the standard range.

Step by step design process:

We started the design by drawing the structural grid in the software.

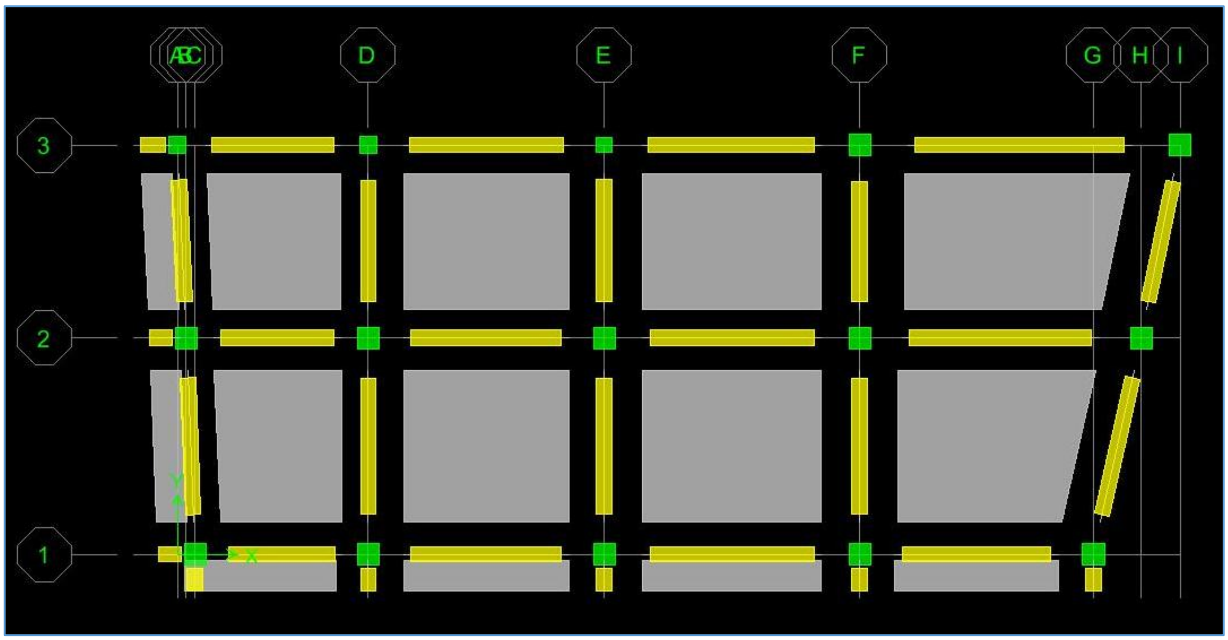
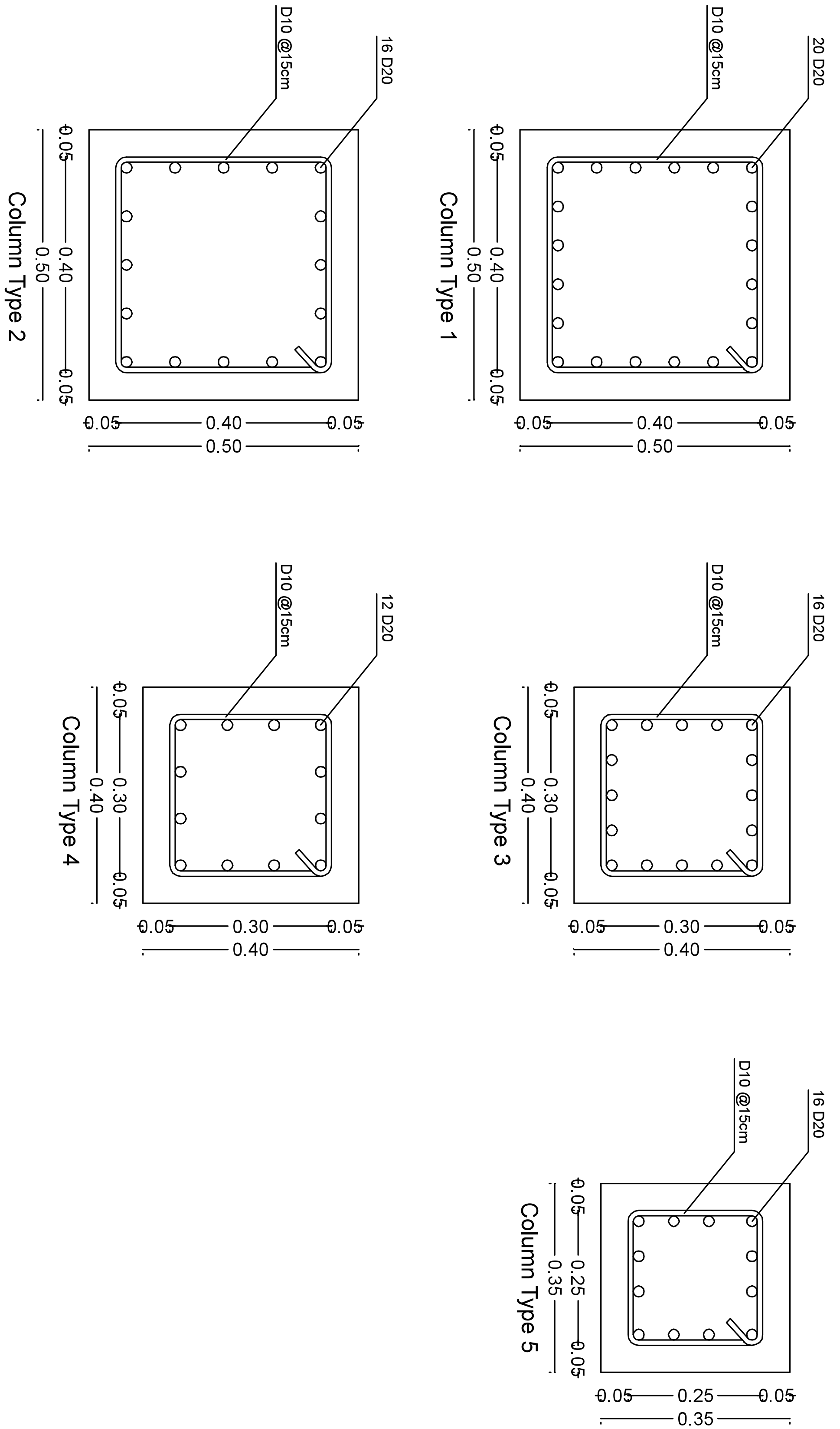


Figure 233 Structural Grid

The sections chosen for the beams are 35x50 with D16, D20, and D25 for the reinforcements to be designed in the software properly. Columns are designed as below for the start of the structural analysis to be selected properly after the first structural analysis.


Column Type 1
20 D20
D10 @15cm
0.05
0.40
0.05
0.50
Column Type 2
16 D20
D10 @15cm
0.05
0.40
0.05
0.50
Column Type 3
16 D20
D10 @15cm
0.05
0.30
0.05
0.40
Column Type 4
12 D20
D10 @15cm
0.05
0.30
0.05
0.40
Column Type 5
16 D20
D10 @15cm
0.05
0.25
0.05
0.35

After the loading according to the design of the floors and walls for the Dead load and the functions for the Live load we start the first structural analysis of the software.

Load Type	Value
External wall (DEAD)	170 Kgf/m^2
Internal wall (DEAD)	50 Kgf/m^2
Floor (DEAD)	450 Kgf/m^2
Green roof (DEAD)	650 Kgf/m^2
Normal floors (LIVE)	150 Kgf/m^2
Roof (LIVE)	150 Kgf/m^2

After the loading in the structural analysis we should check the critical points to see if the point displacements and the story drift is in the standard range. For our case it is happening because we are having a normal almost symmetrical structure with short spans. The deformed shape of the structure under the dead load as an example is like the image below.

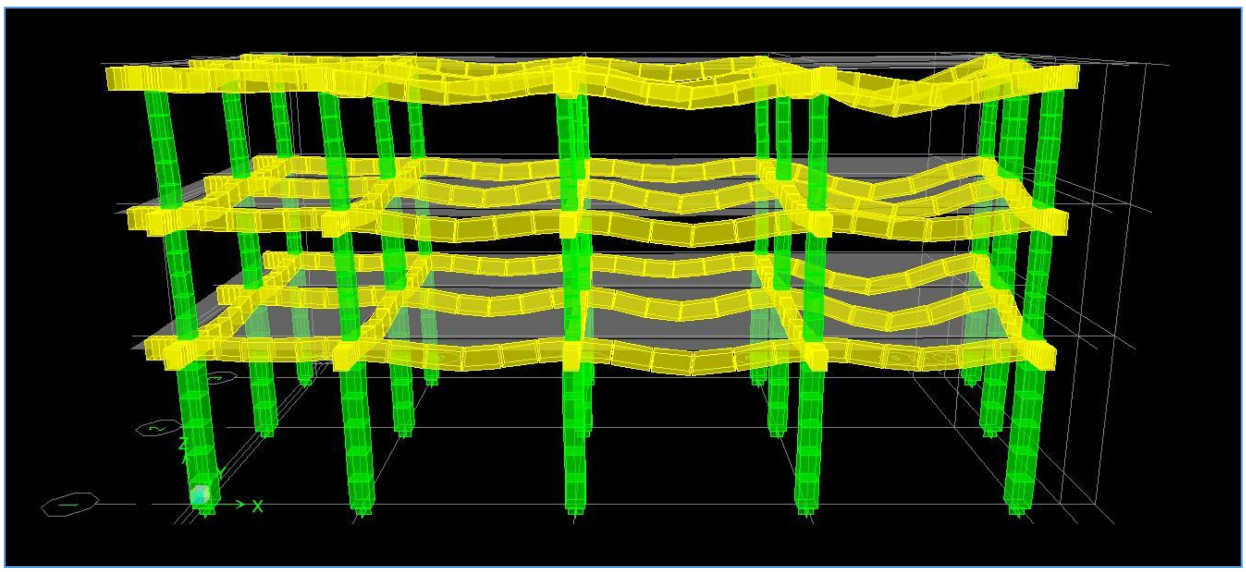


Figure 234 Structure Deformation

In the software it is possible to get all the structural calculations including the bending moments, shear forces, and axial forces for all the elements if needed. As an example here are all the diagrams for frame 1 from the software.

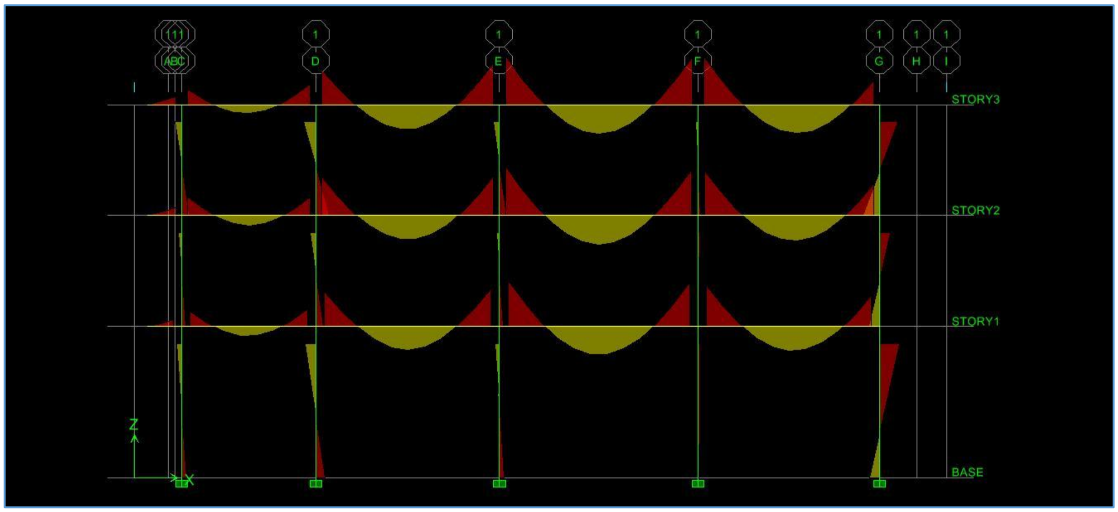


Figure 235 Bending moment diagram around 3-3 axis

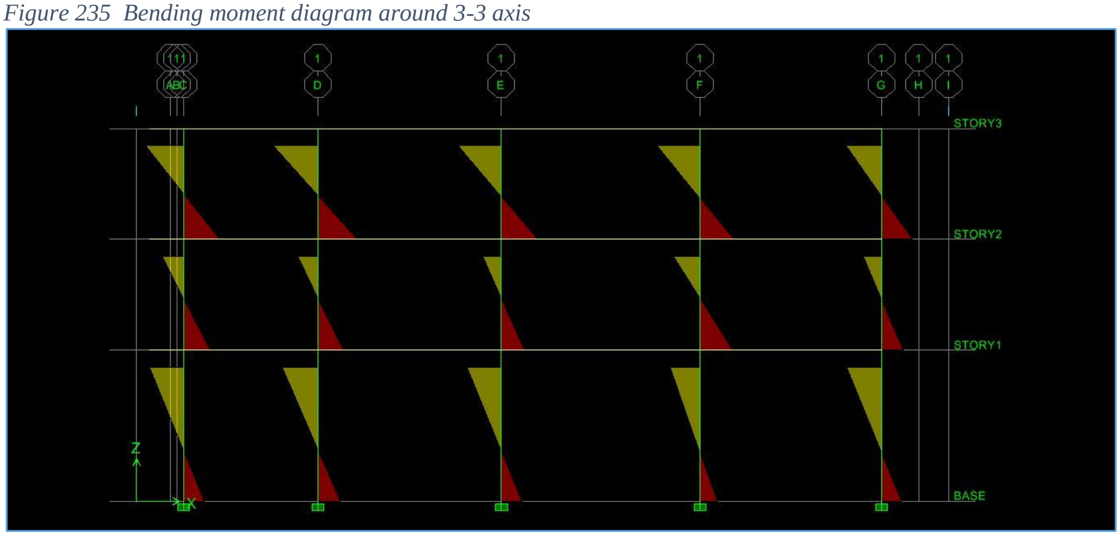


Figure 236 Bending moment diagram around 2-2 axis

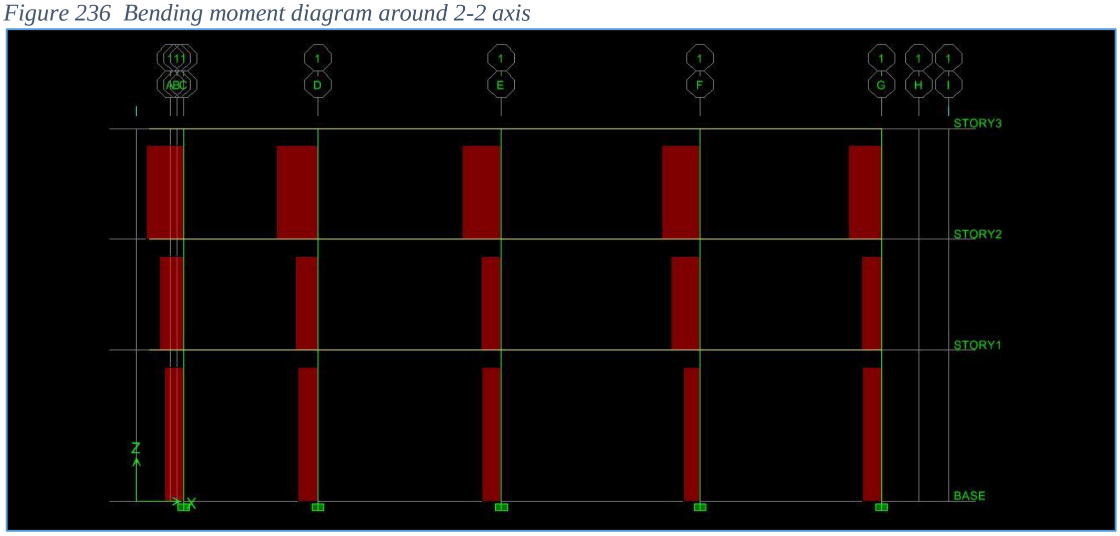


Figure 237 Shear forces diagram around 3-3 axis

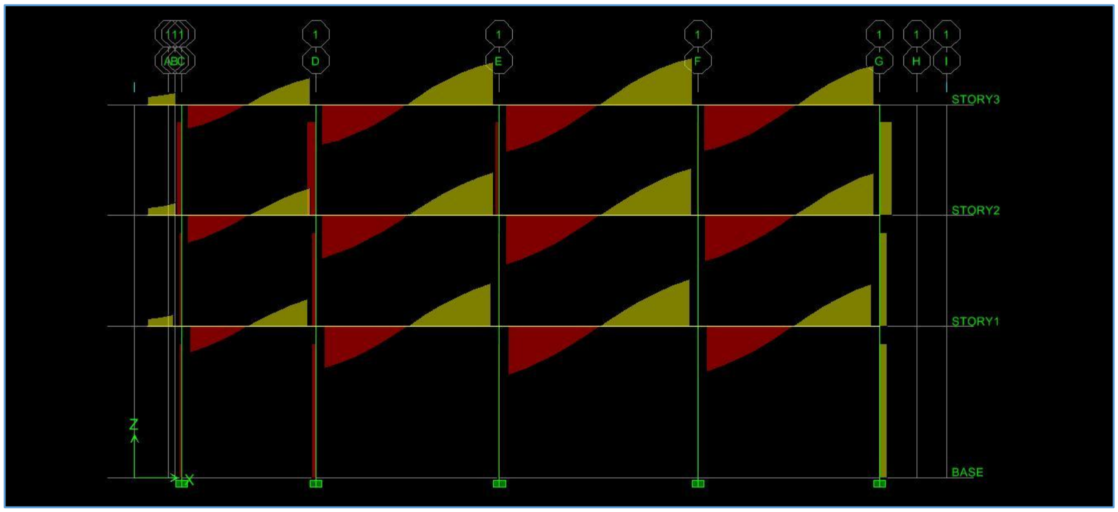


Figure 238 Shear forces diagram around 3-3 axis

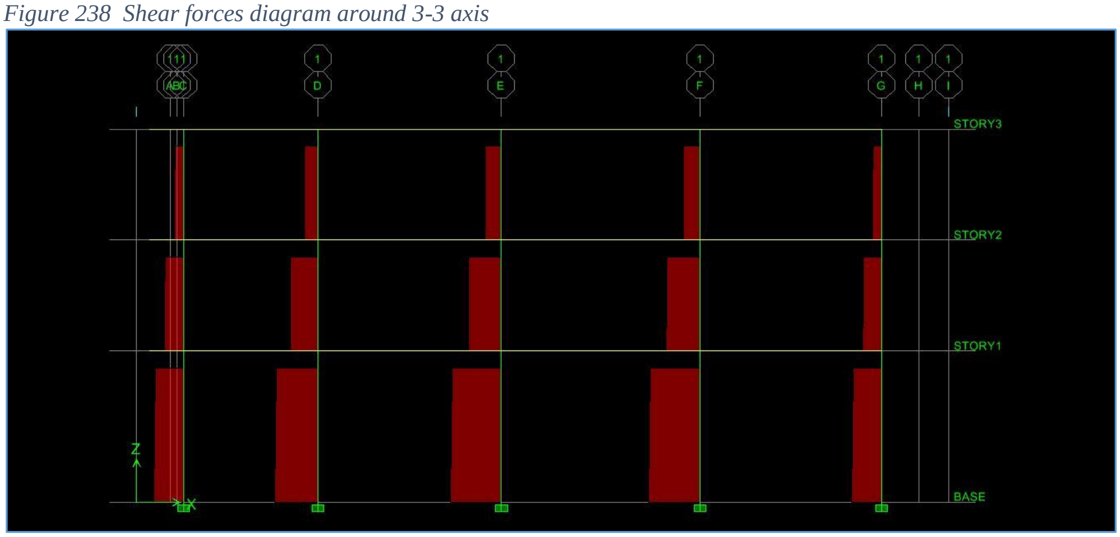
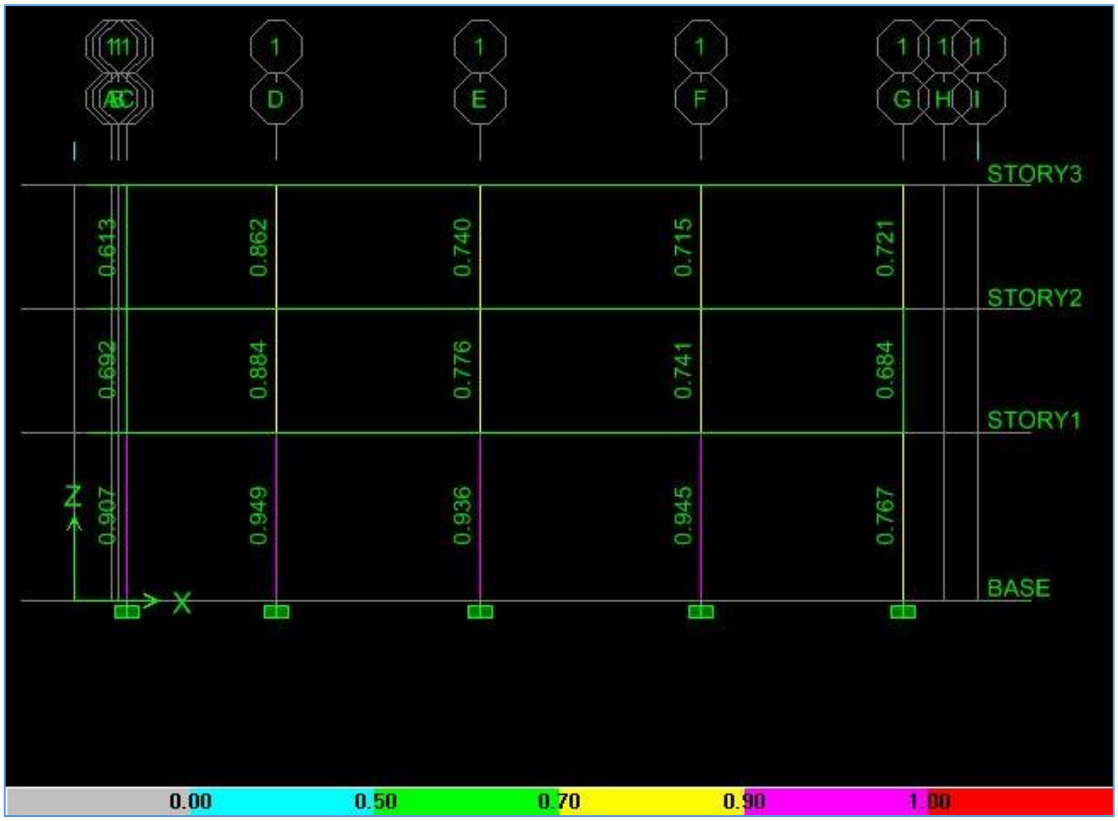
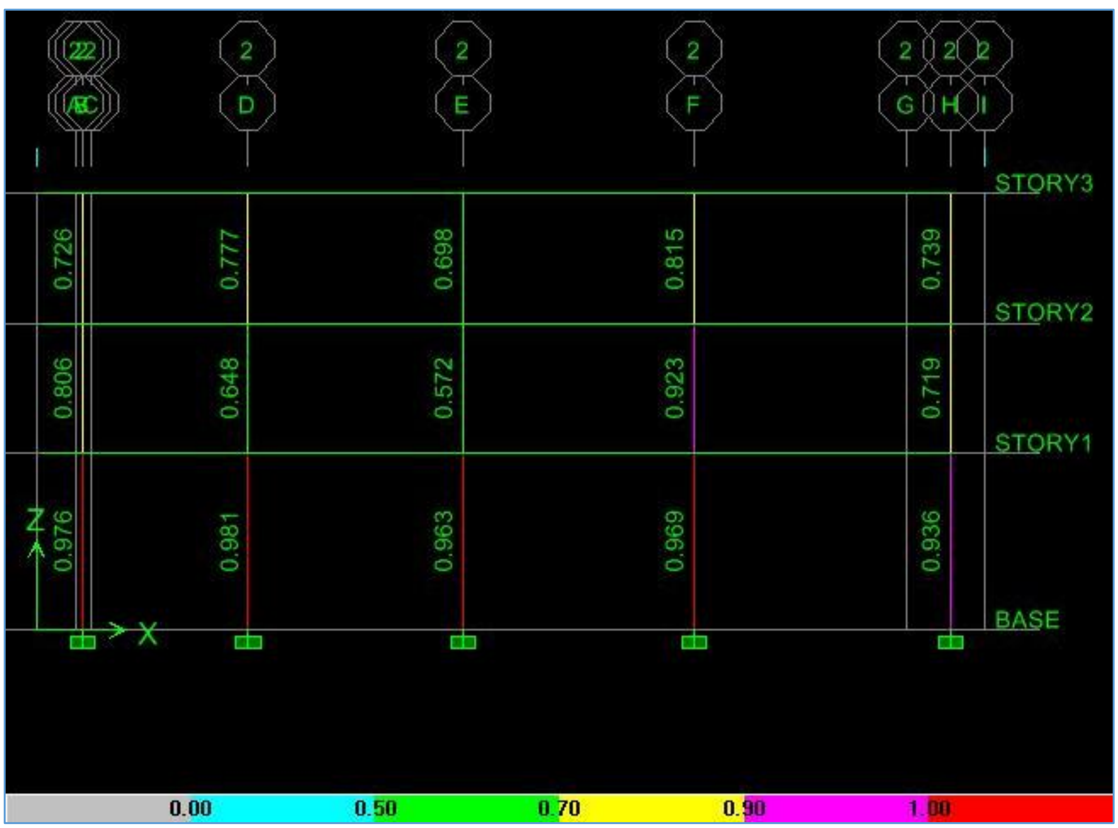
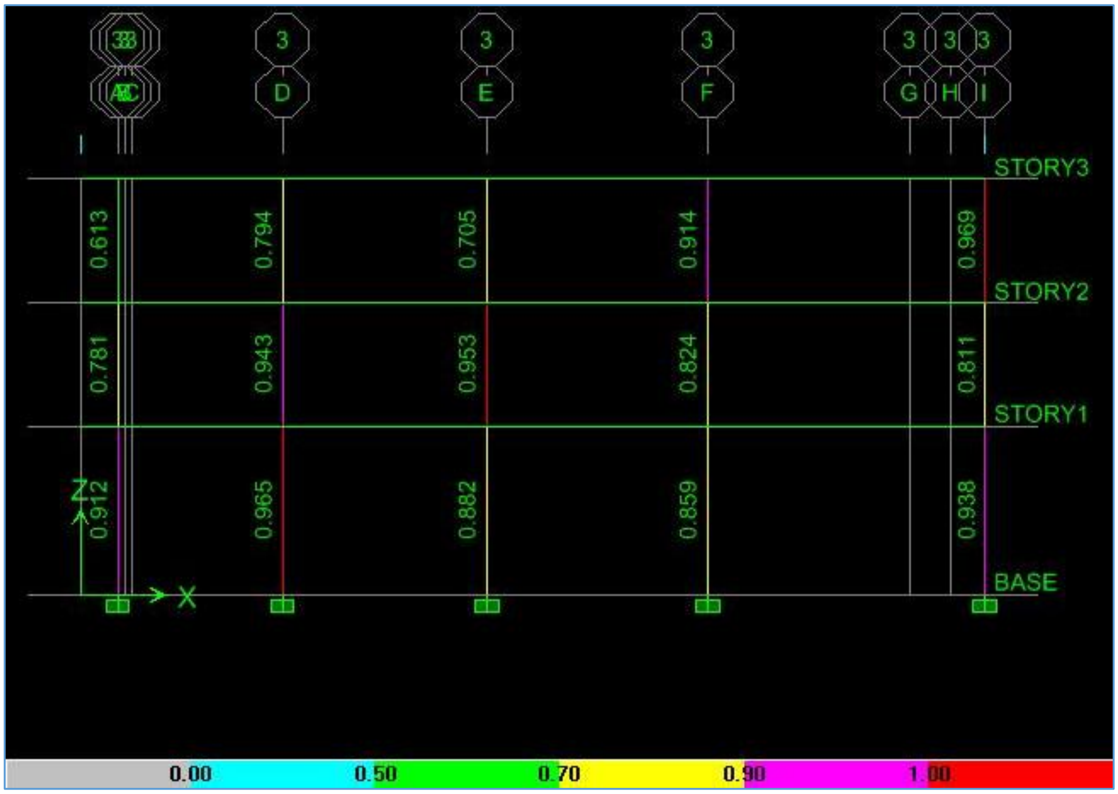


Figure 239 Axial forces diagram

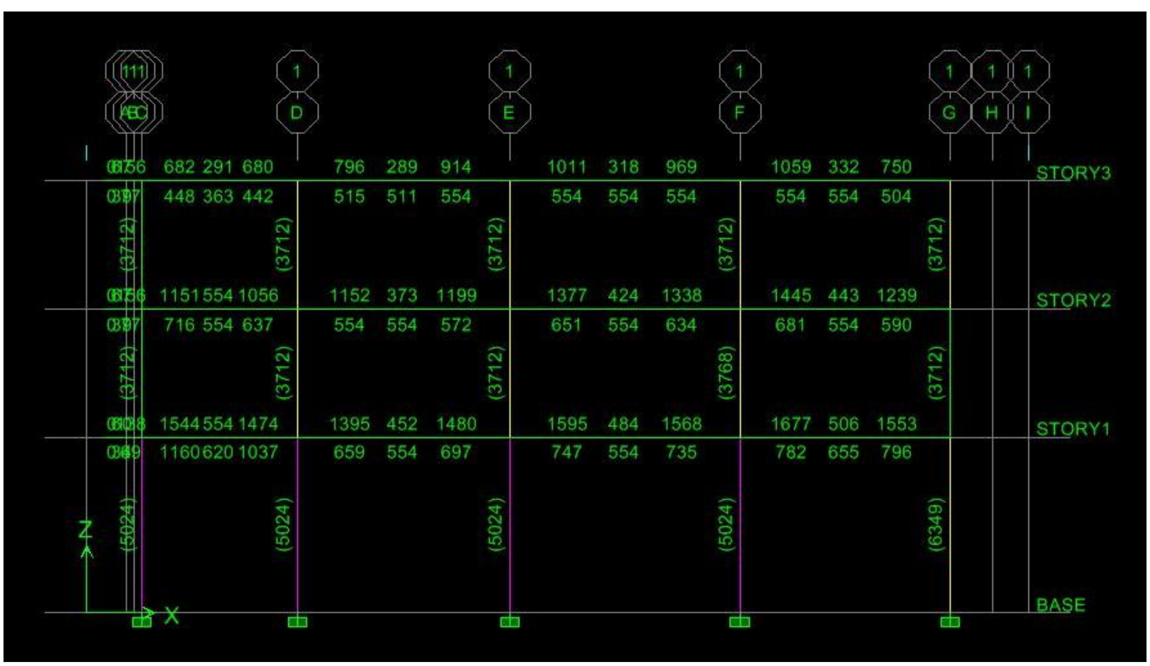
In the capacity-ratio design for the column, we start designing the columns by choosing the most economical, functional section for each specific column then we try to categorize them in order to have less different types of columns which makes it easier and more practical to be built in reality. The capacity-ratio needs to be the closest to the value 1 not more than that, the best range is in the range of 0.9 to 1. If it is more than 1, it means that it is not resisting under the existing loads, and if it is far less than 0.9 means the section is overdesigned and the section area and/or the reinforcements are more than enough which is not economic and also it increases the weight of the building.


1
1
1
1
1
1
1
1
A
B
C
D
E
F
G
H
I
STORY3
STORY2
STORY1
BASE
0.613
0.862
0.740
0.715
0.721
0.692
0.884
0.776
0.741
0.684
0.907
0.949
0.936
0.945
0.767
Z
X
0.00
0.50
0.70
0.90
1.00

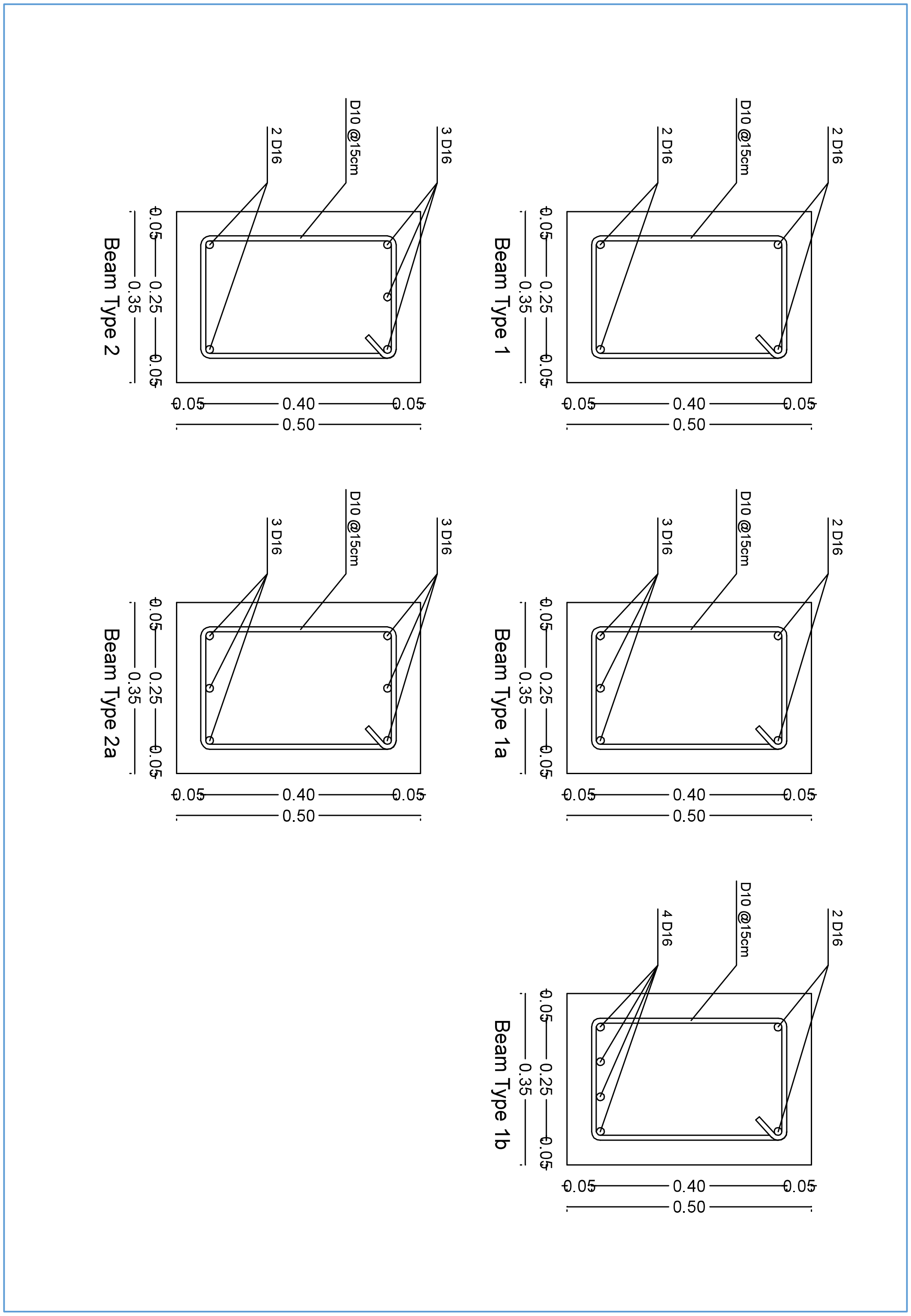

2
2
2
2
2
2
2
2
A
B
C
D
E
F
G
H
I
STORY3
STORY2
STORY1
BASE
0.726
0.777
0.698
0.815
0.739
0.806
0.648
0.572
0.923
0.719
0.976
0.981
0.963
0.969
0.936
Z
X
0.00
0.50
0.70
0.90
1.00

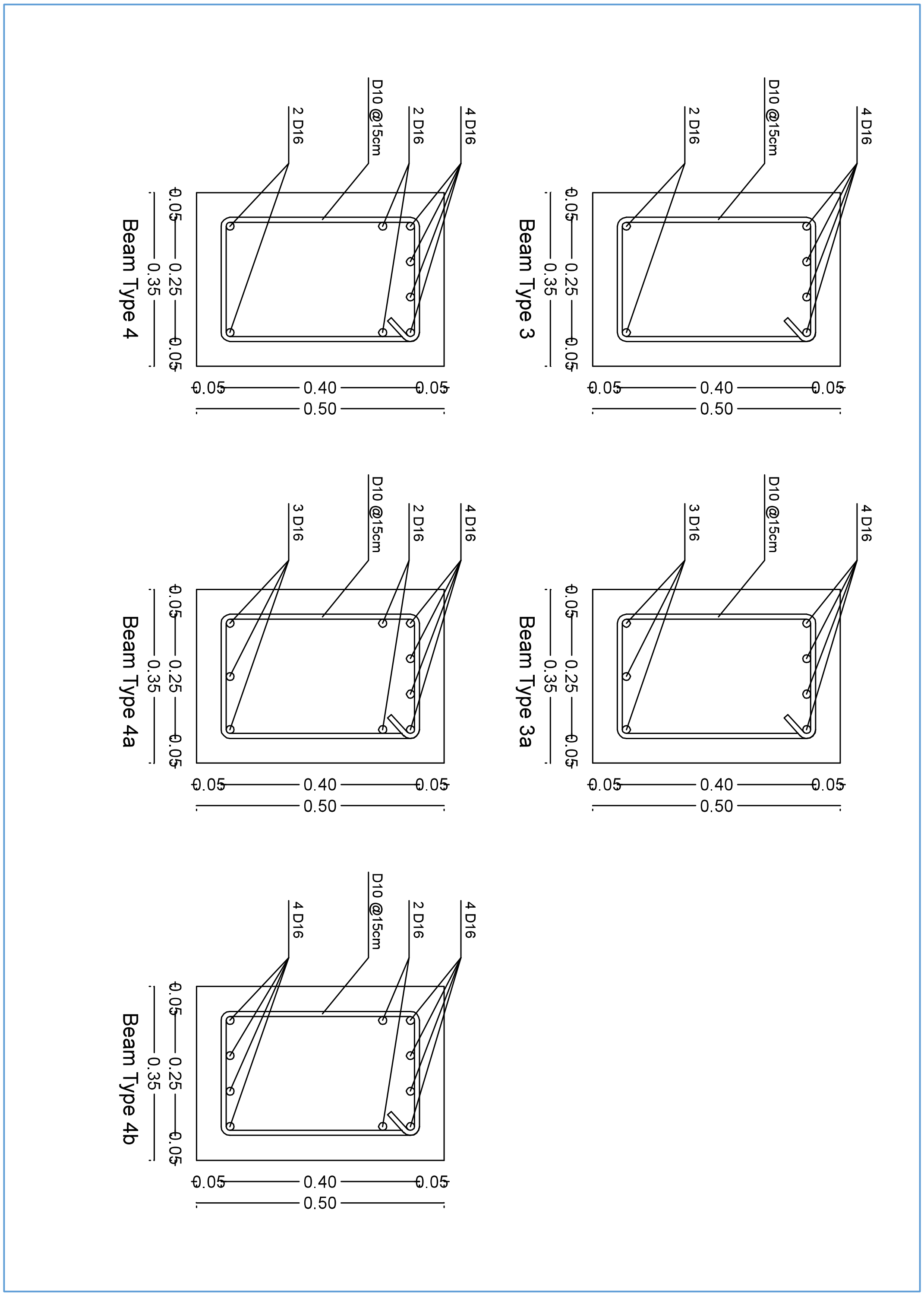


After choosing the column sections we started designing the beams in the software to get the values for the bending and the shear reinforcements. As an example for frame 1 the values for the bending reinforcements in square millimeters are as below

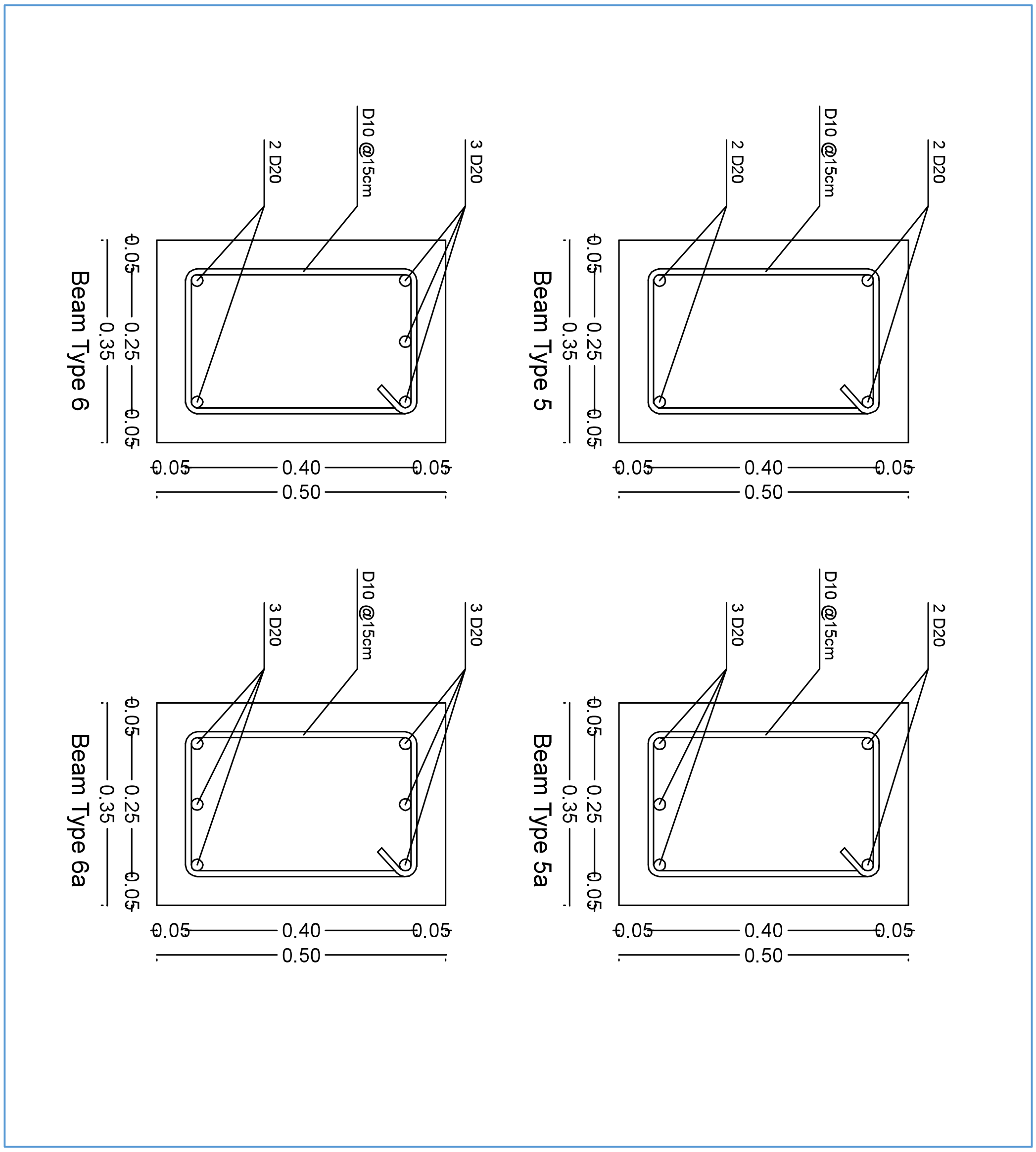


The values above helps us chose a section with enough reinforcement from the tables also considering the cover of the concrete and the distance between each two bars. The final results for the reinforcement of the beams are as below.

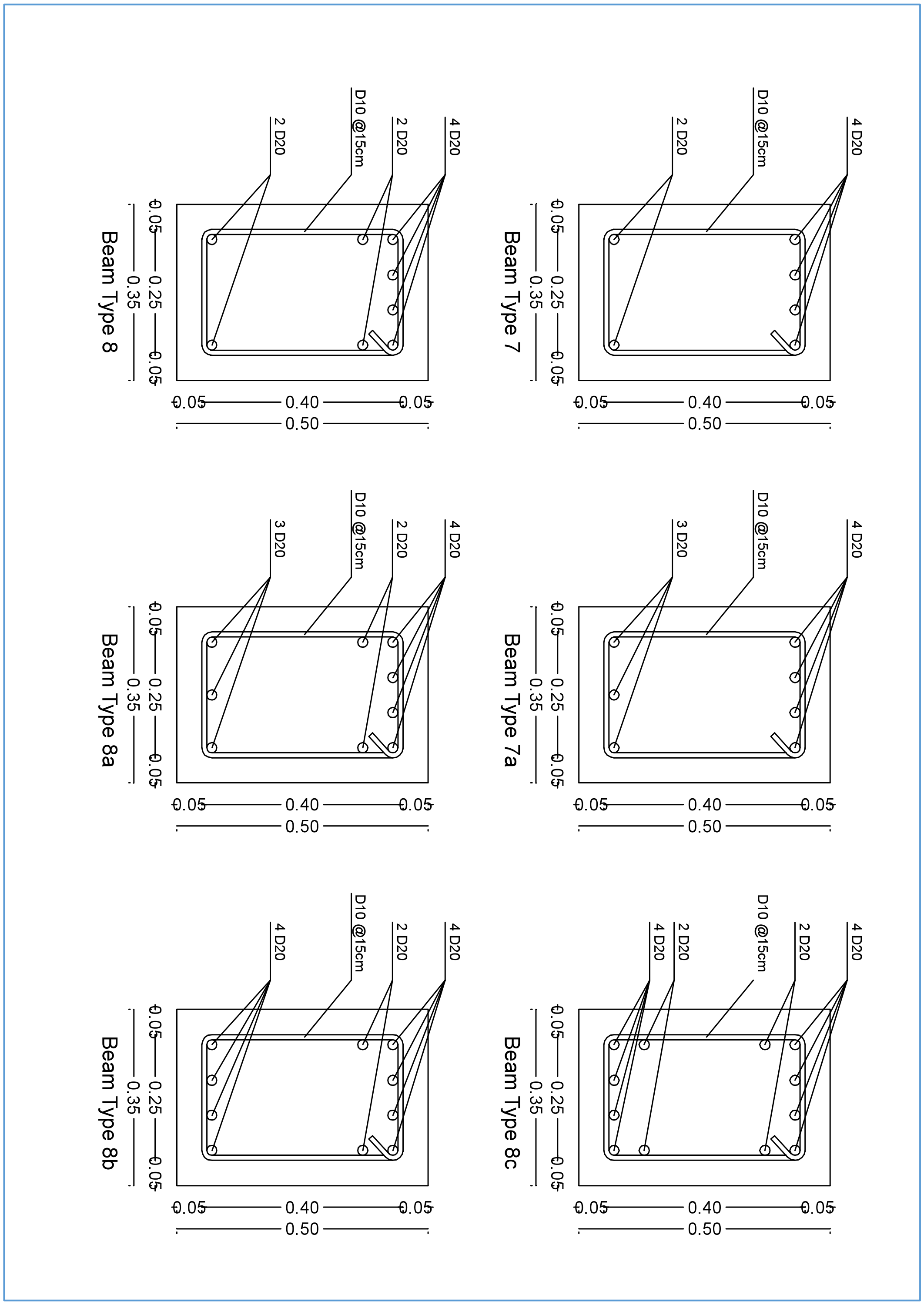


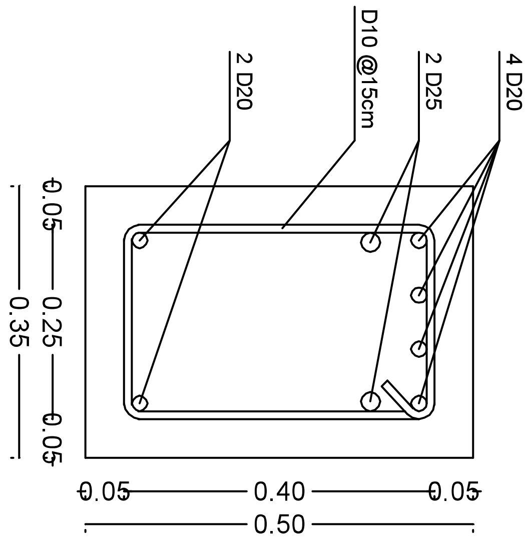


Beam Type 4
Beam Type 3
Beam Type 4a
Beam Type 3a
Beam Type 4b
2 D16
3 D16
4 D16
D10 @15cm
0.05
0.25
0.35
0.40
0.50

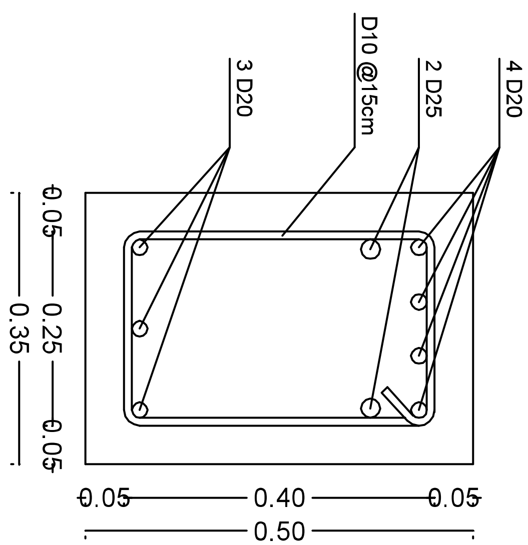


Beam Type 6
2 D20
D10 @15cm
3 D20
0.05
0.25
0.35
0.40
0.50
Beam Type 5
2 D20
D10 @15cm
2 D20
Beam Type 6a
3 D20
D10 @15cm
3 D20
Beam Type 5a
3 D20
D10 @15cm
2 D20

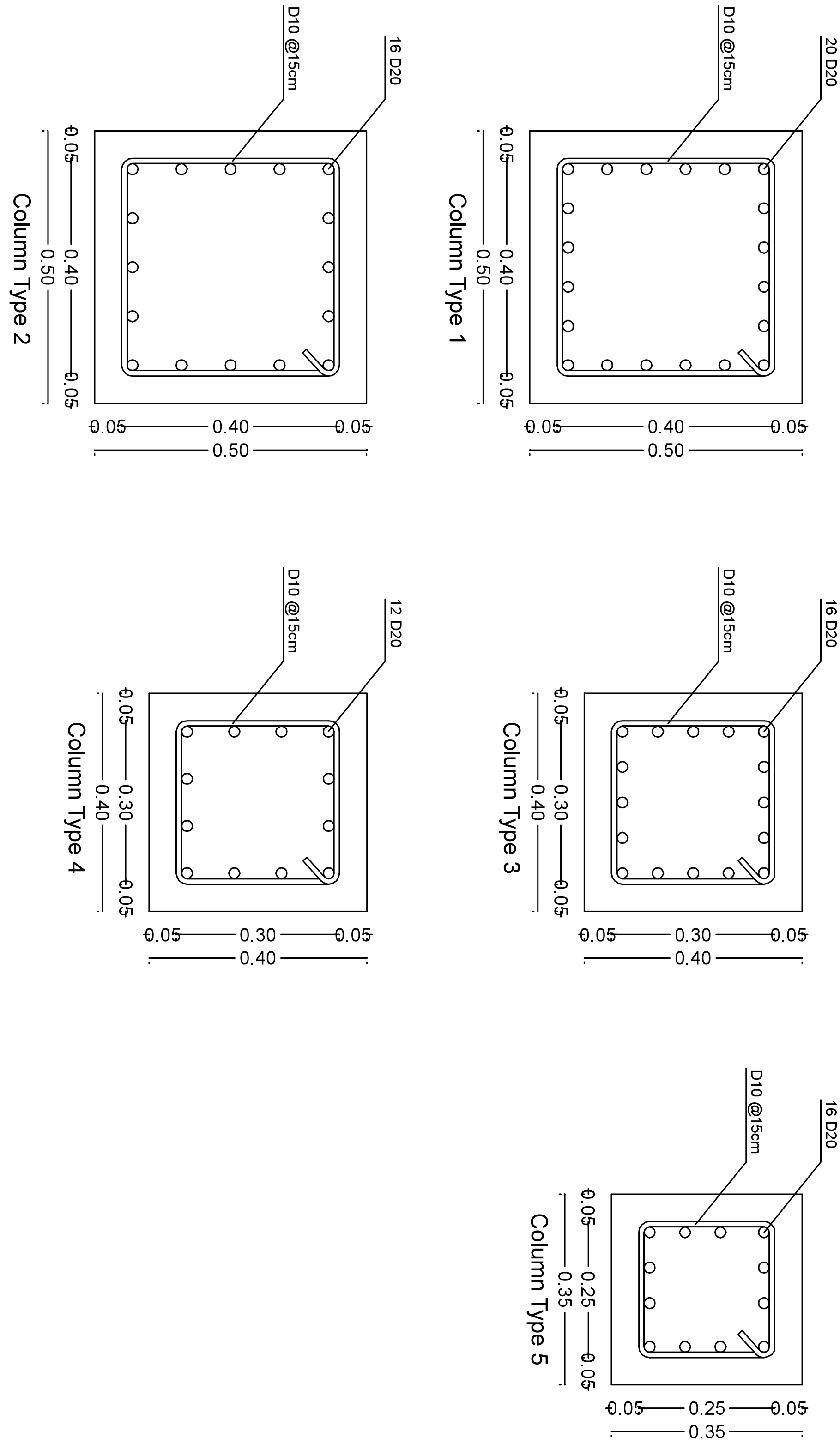

Beam Type 7
Beam Type 8
Beam Type 7a
Beam Type 8a
Beam Type 8b
Beam Type 8c
D10 @15cm
4 D20
2 D20
3 D20
0.05
0.40
0.50
0.25
0.35



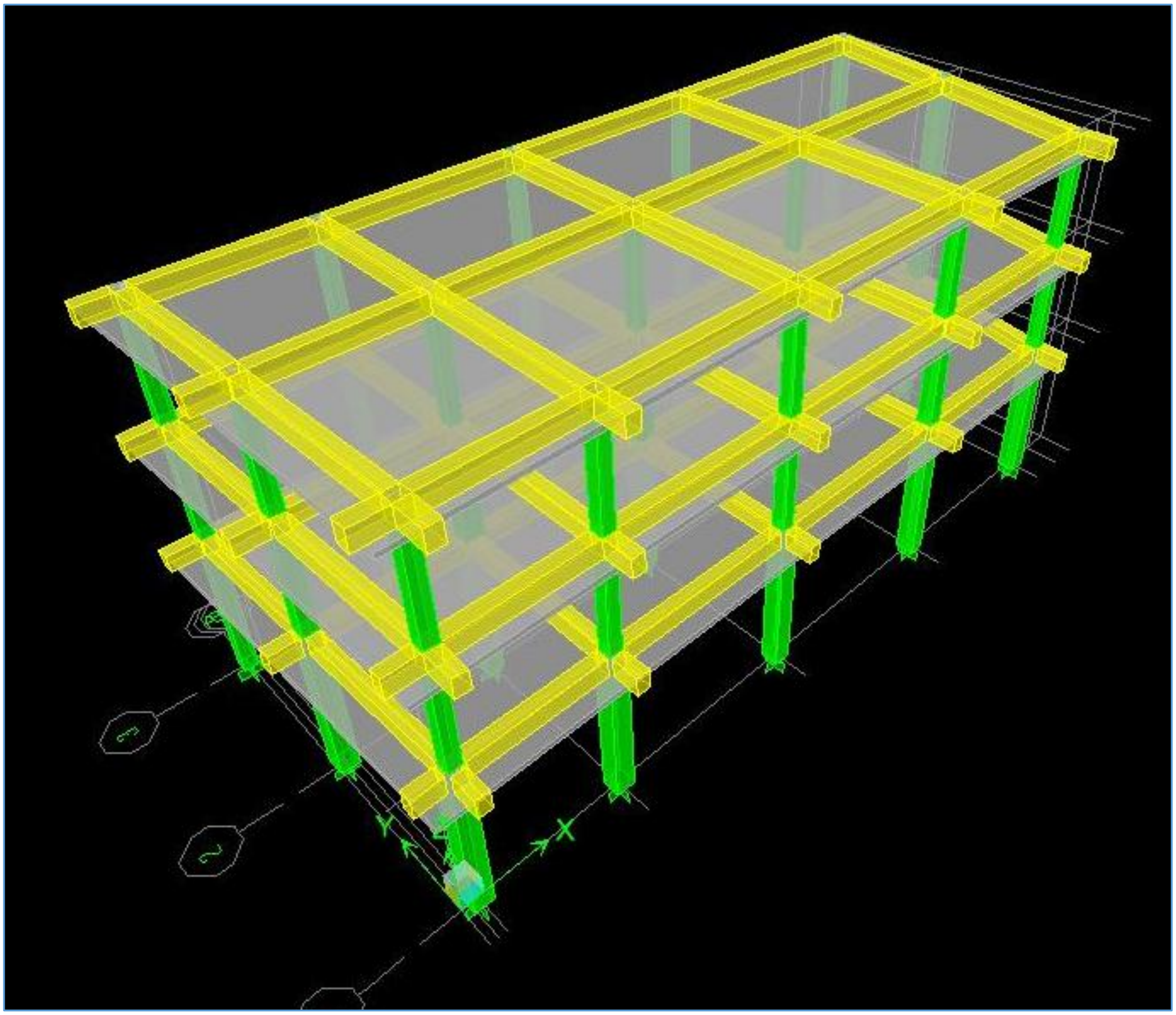
Beam Type 9

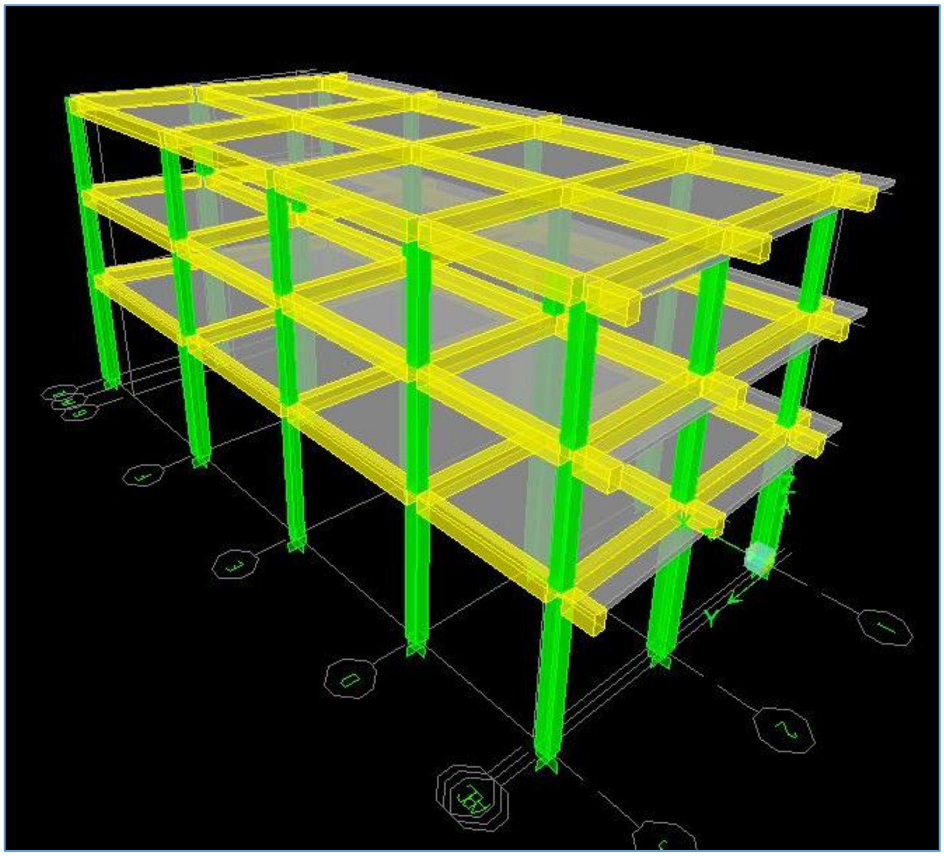


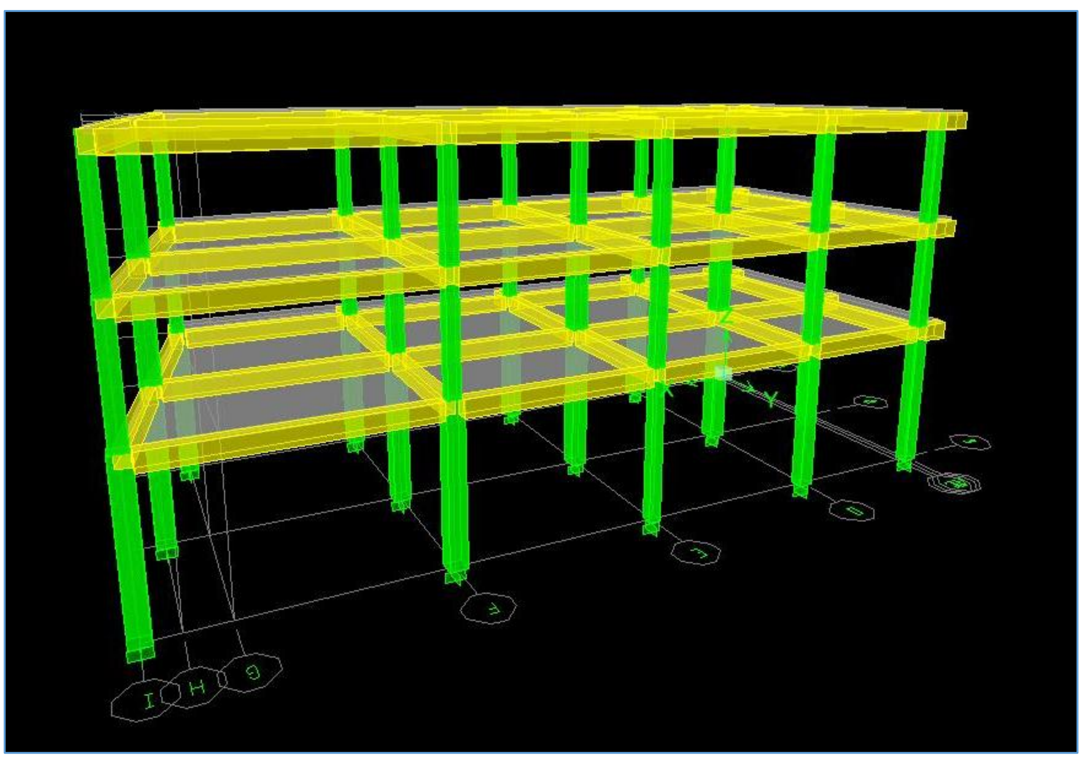
Beam Type 9a

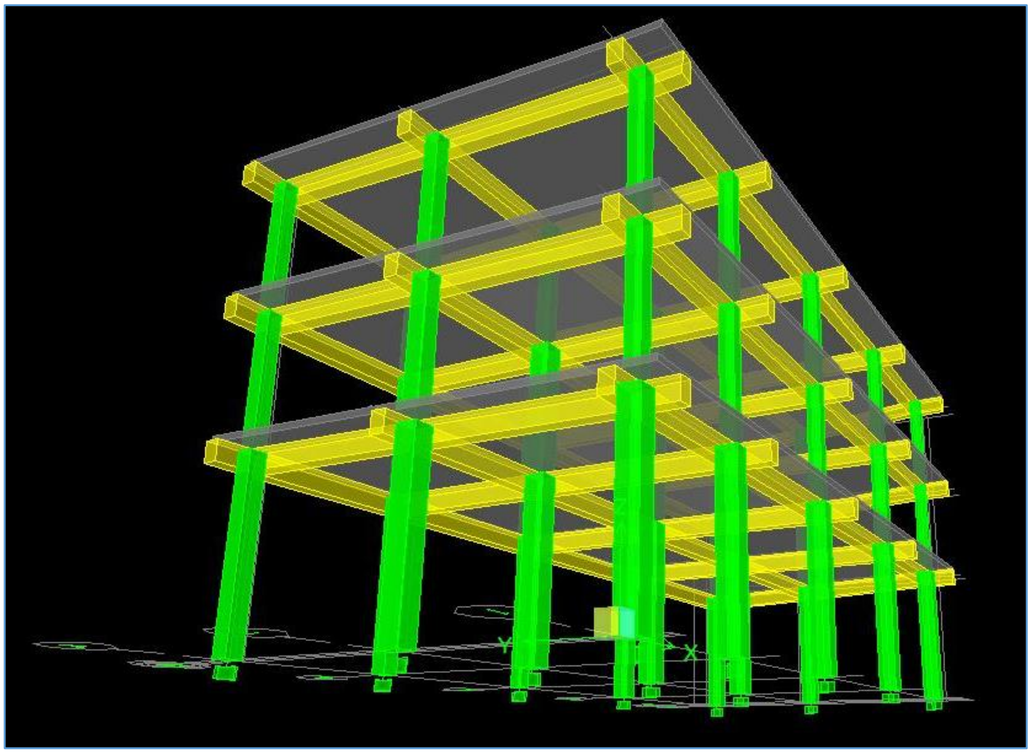

Column Type 1
20 D20
D10 @15cm
0.05 0.40 0.05
0.50
Column Type 2
16 D20
D10 @15cm
0.05 0.40 0.05
0.50
Column Type 3
16 D20
D10 @15cm
0.05 0.30 0.05
0.40
Column Type 4
12 D20
D10 @15cm
0.05 0.30 0.05
0.40
Column Type 5
16 D20
D10 @15cm
0.05 0.25 0.05
0.35

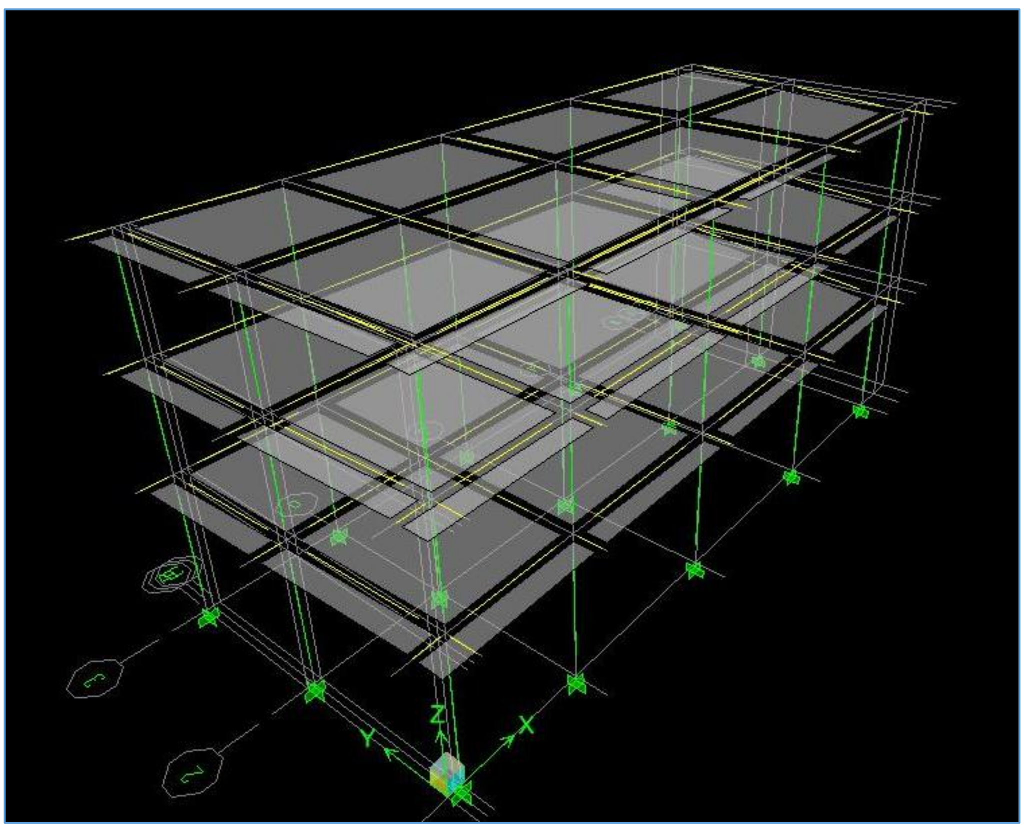
Finally renders from the software and the sections of all the structural frames with the details of the sections of the beams and columns are as below.

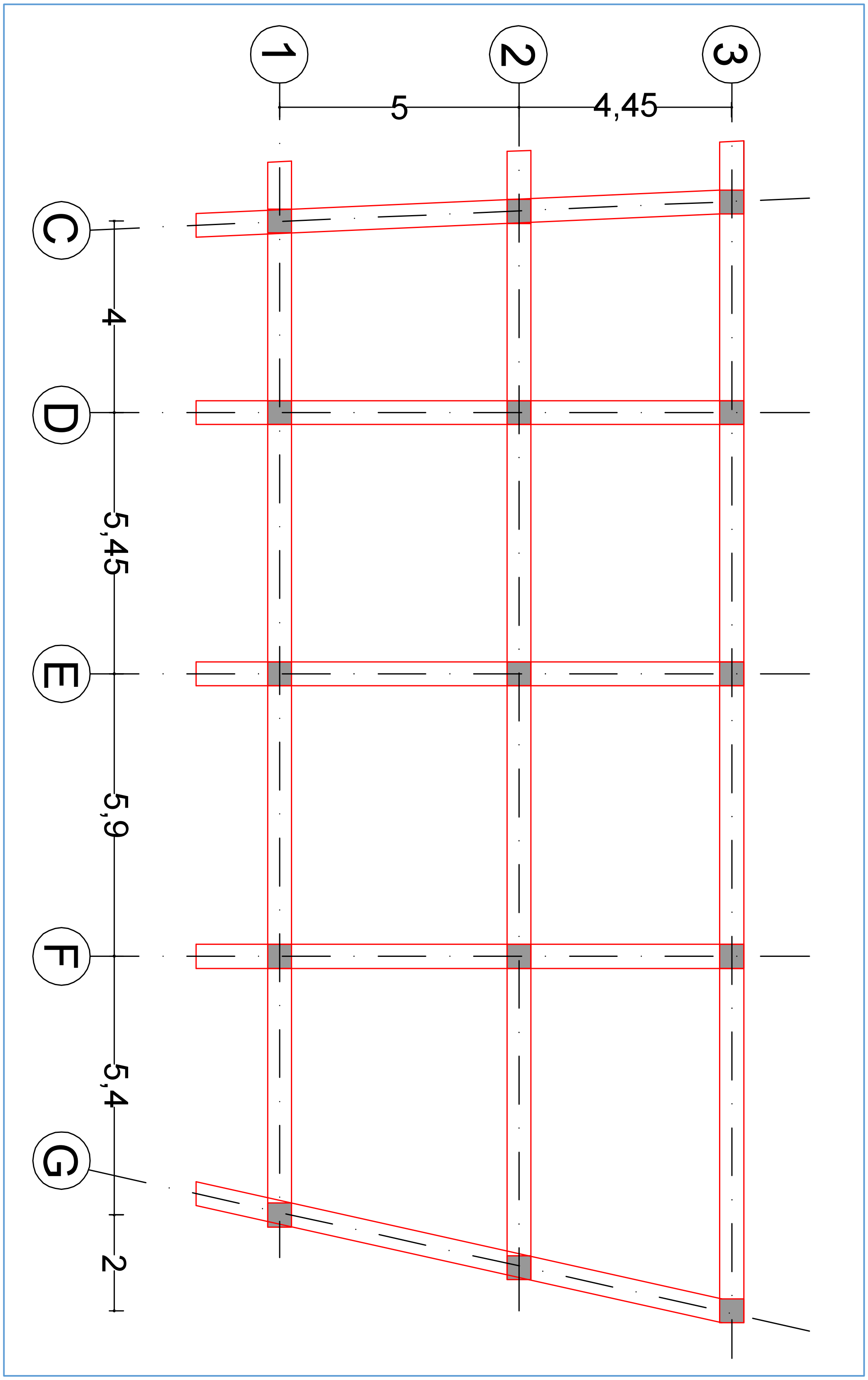


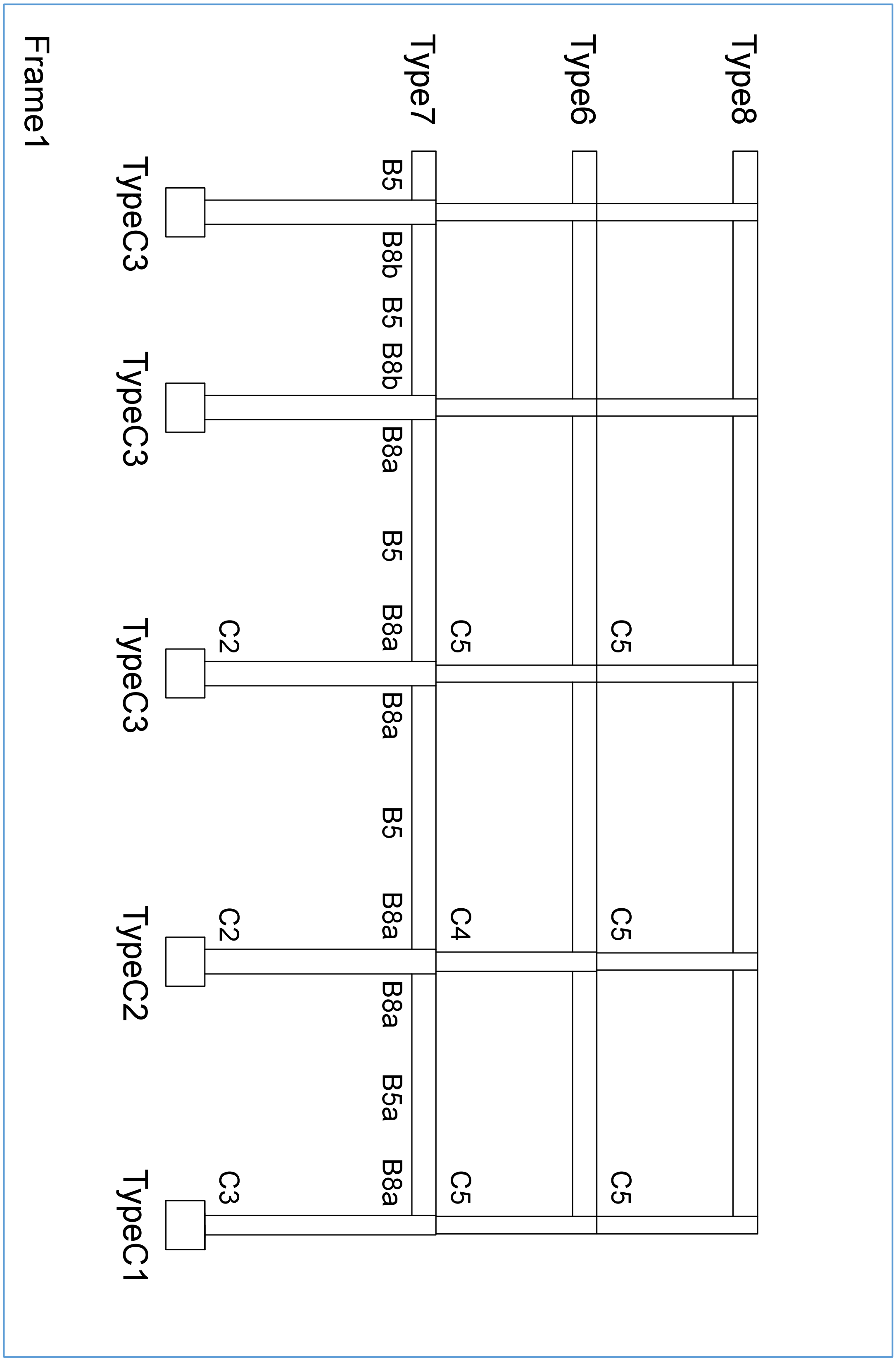


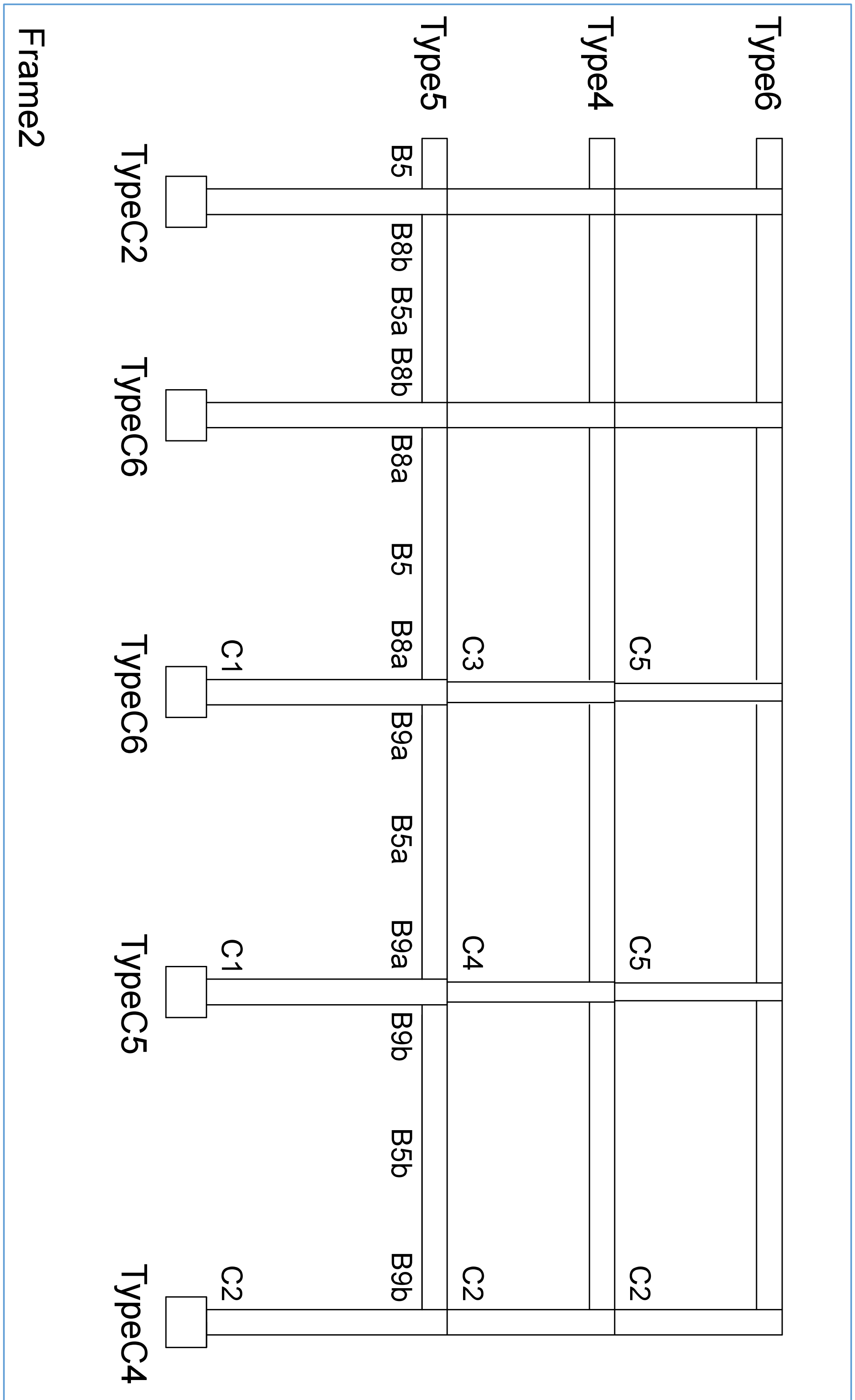

I
H
G



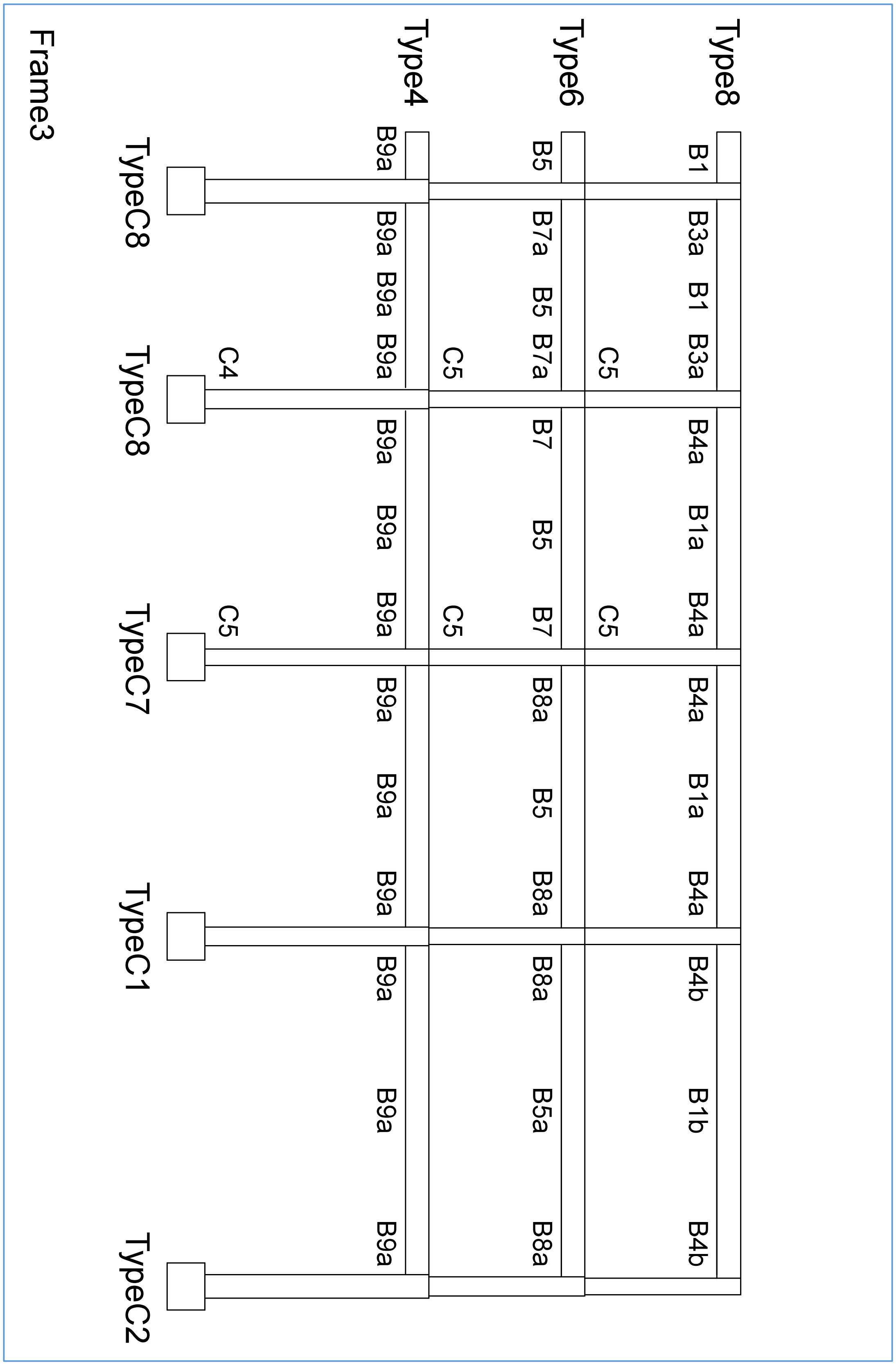


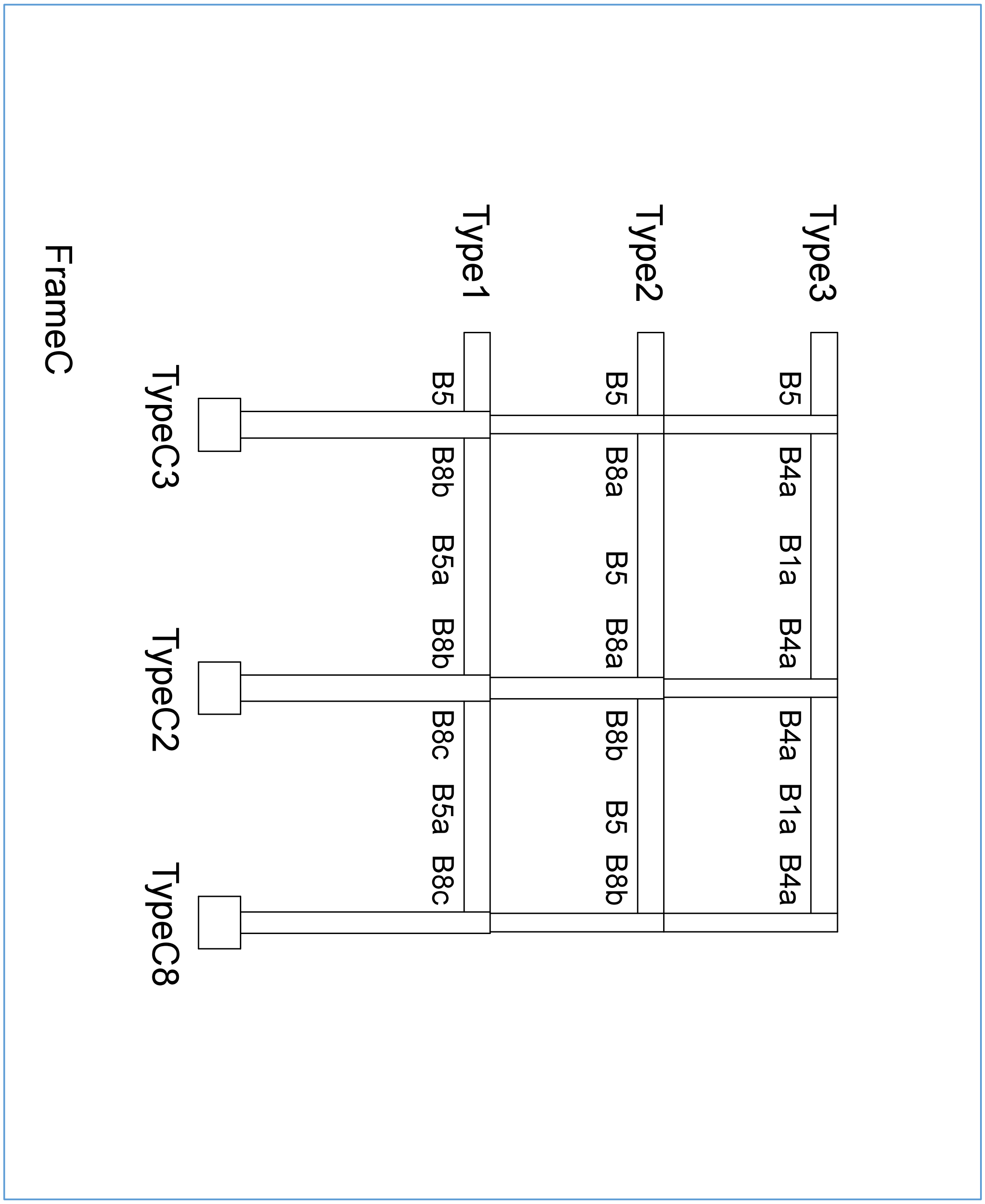

1
2
3
5
4,45
C
D
E
F
G
4
5,45
5,9
5,4
2

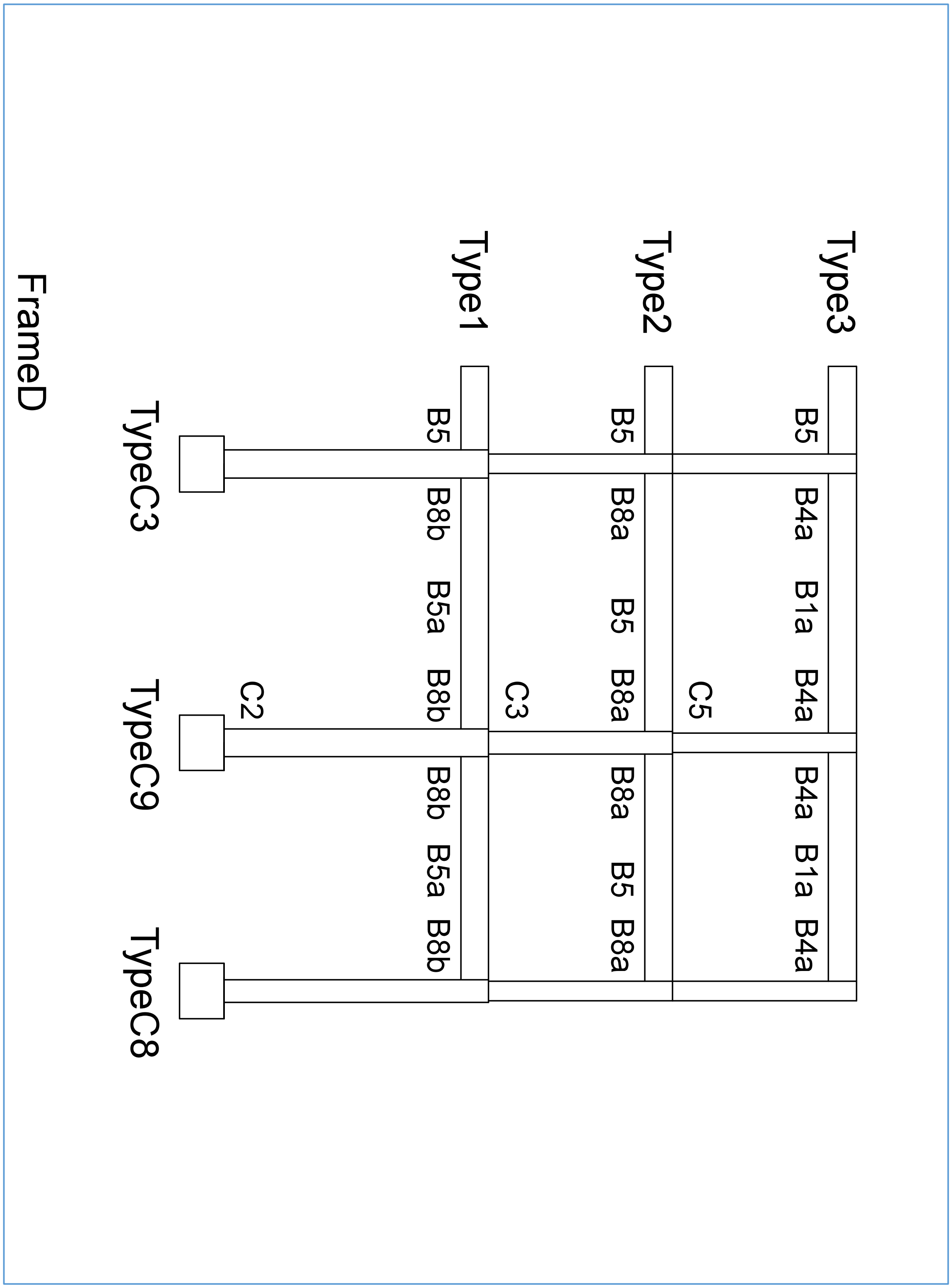

Frame1
Type8
Type6
Type7
B5
B8b
B5
B8b
B8a
B5
B8a
B8a
B5
B8a
B8a
B5a
B8a
C5
C5
C4
C5
C5
C5
C5
C2
C2
C3
TypeC3
TypeC3
TypeC3
TypeC2
TypeC1

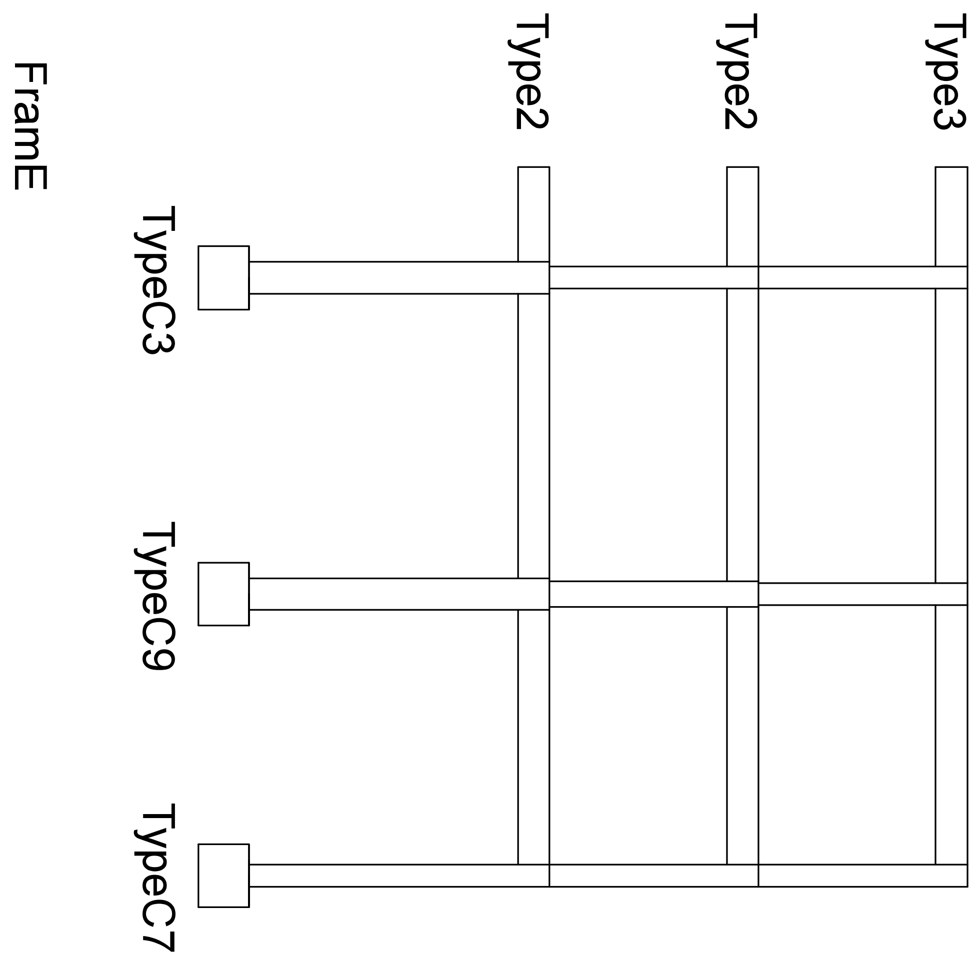


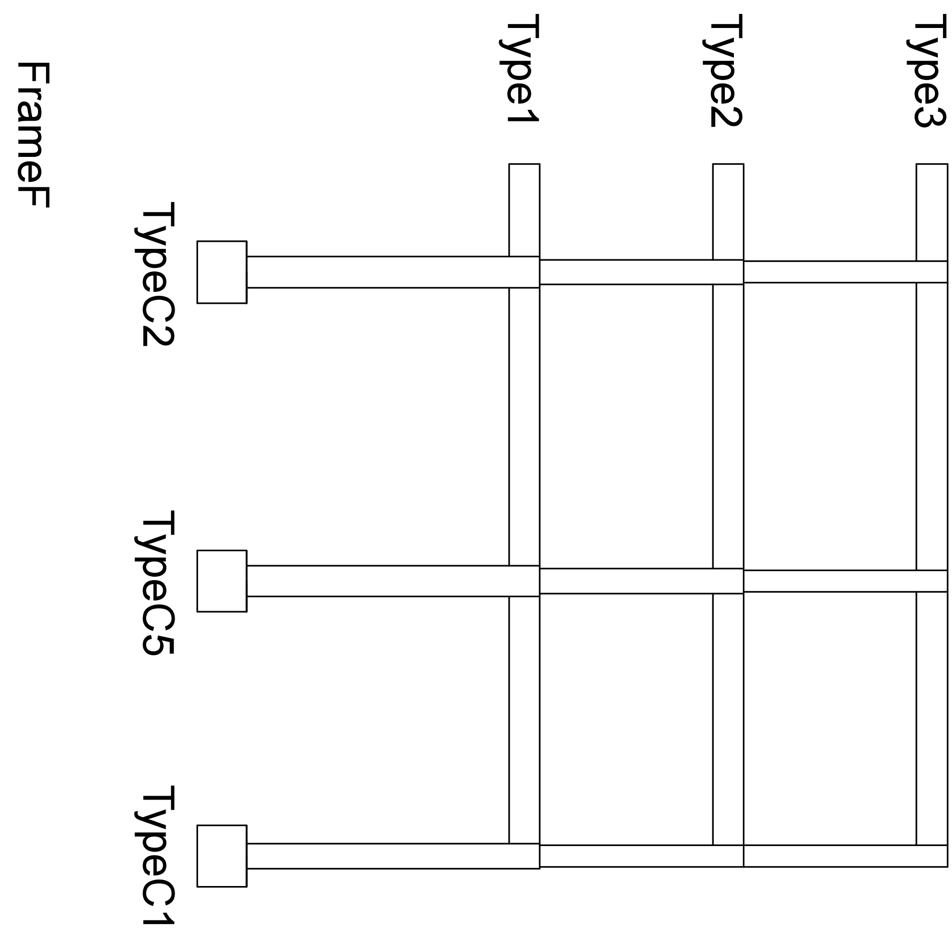
Frame2
Type6
Type4
Type5
B5
B8b
B5a
B8b
B8a
B5
B8a
B9a
B5a
B9a
B9b
B5b
B9b
C5
C5
C2
C3
C4
C2
C1
C1
C2
TypeC2
TypeC6
TypeC6
TypeC5
TypeC4


Frame3
Type8
Type6
Type4
B1 B3a B1 B3a B4a B1a B4a B4a B1a B4a B4b B1b B4b
B5 B7a B5 B7a B7 B5 B7 B8a B5 B8a B8a B5a B8a
B9a B9a B9a B9a B9a B9a B9a B9a B9a B9a B9a B9a B9a
C5 C5
C5 C5
C4 C5
TypeC8
TypeC8
TypeC7
TypeC1
TypeC2


FrameC
Type3
B5 B4a B1a B4a B4a B1a B4a
Type2
B5 B8a B5 B8a B8b B5 B8b
Type1
B5 B8b B5a B8b B8c B5a B8c
TypeC3
TypeC2
TypeC8


FrameD
Type3
Type2
Type1
B5 B4a B1a B4a B4a B1a B4a
B5 B8a B5 B8a B8a B5 B8a
B5 B8b B5a B8b B8b B5a B8b
C5
C3
C2
TypeC3
TypeC9
TypeC8


FramE
Type2
Type2
Type3
TypeC3
TypeC9
TypeC7


FrameF
Type1
Type2
Type3
TypeC2
TypeC5
TypeC1

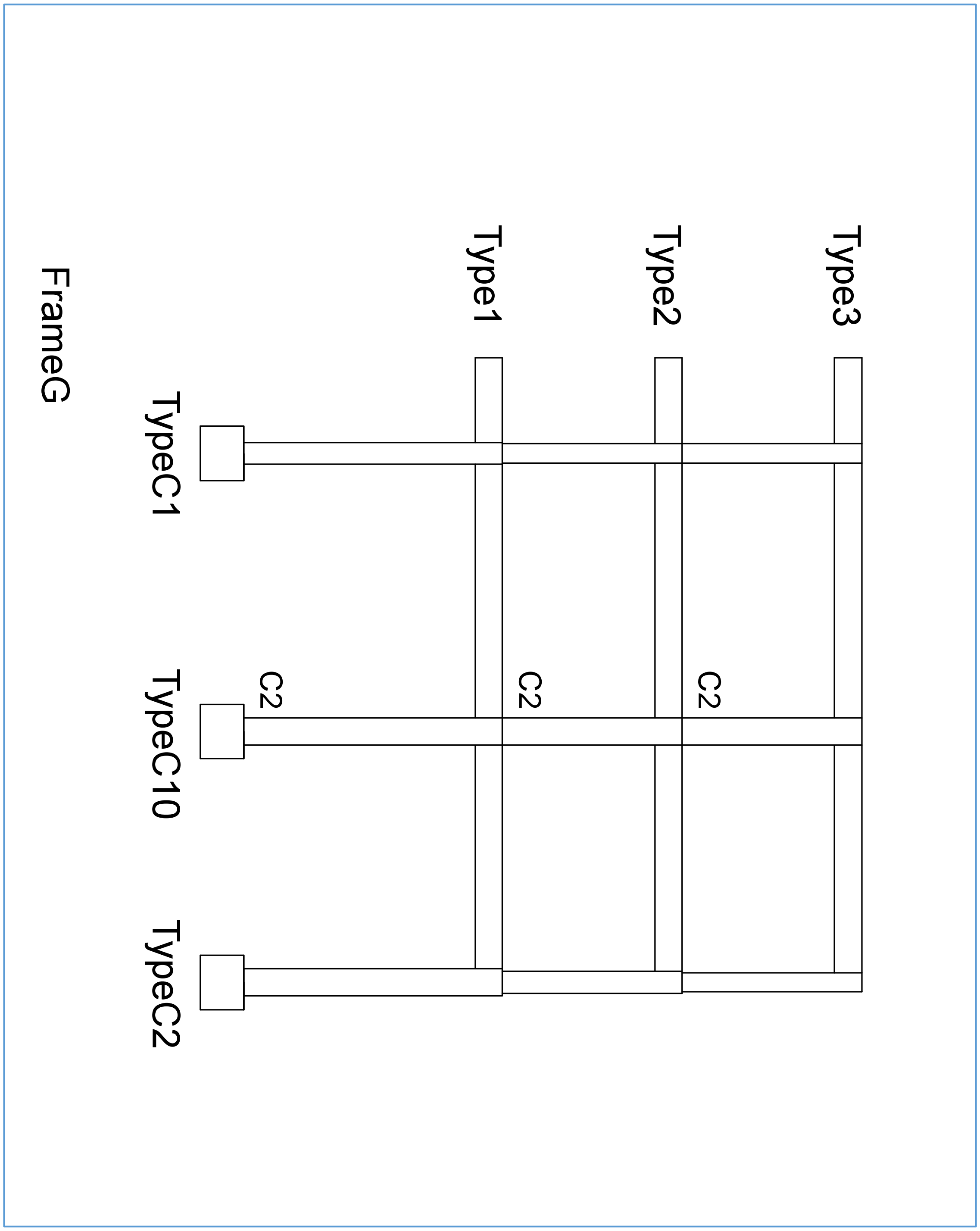

FrameG
Type1
Type2
Type3
TypeC1
TypeC10
TypeC2
C2
C2
C2

Table of Figures