Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

LEVEL 4 ASSIGNMENT

Student Name:	MOHAMED ELHADI HUSSIEN SALIM
Student ID number:	2511440
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Lecturer:	Allan Nantel
Internal Verifier:	Rhodri Thomas
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Selected Structure: Rogers Steven's Building University of Leeds (Concrete Structure)

The Roger Stevens Building at the university of Leeds, completed in 1970 by architects Chamberlin, Powell and Bon. It was designed as a central lecture theatre hub, utilizing raw concrete and a distinctive, irregular, multi-level footprint that separates pedestrian traffic from vehicle access. Designed as part of the South Campus expansion, featuring a distinctive, angular concrete design, typical of the 1970s Brutalist style. It serves as a central lecture block, designed to accommodate large numbers of students across various levels. Characterized by its raw concrete the building is frequently associated with a nearby pond, forming a key aesthetic, and functional, part of the campus layout. The building remains a notable, listed example of modern, post-war, university, architecture, in the United Kingdom.

Predominantly constructed using reinforced concrete is utilized for its piers and walls, which in turn support in-situ concrete beams and slabs, forming the building's core infrastructure often employing Ordinary Portland Cement (OPC). Concrete plays a key structural role in creating the floors and ceilings, extending further to incorporate built-in seats and benches within the lecture theatres. The building is renowned for its distinctive organ-pipe ventilation ducts and recessed balconies, crafted entirely from concrete. These elements contribute to its bold and striking silhouette.

Historic England Archive: DP158134

Framing Material

- Concrete resisting compression. $20 - 50MPa$
- Steel reinforcement (rebar) sustaining cracking and tension loads.

$$\sim 440 - 550MPa\ UTS\ (ultimate\ tensile\ strength)$$

The building Structural strength is based on reinforced concrete, a composite that uses steel to assist the material bearing capacity to handle both tension and compression

Concrete Strength is commonly used, with standard 28-day cube strengths as it gains maximum strength for reinforced concrete ranging from 21 $N/mm$to 31 N/mm. Steel Reinforcement the steel was like plain round mild steel with a yield stress of 250 N/mm or cold-worked deformed bars offering yield ranges between 415 and 485 N/mm.

Durability

Concrete Cover at the time, beams and columns required a minimum cover of 25 mm or with additional 13mm for external or more aggressive environmental conditions, relative to British Standards 1934 and 1948 code guidelines.

Surface Protection The buildings concrete has since been painted to improve its durability by showing carbonation, which can reduce concrete alkalinity and expose steel reinforcement to rust over time offering longer life design period.

Climatic Resistance and Environmental impact

The Roger Stevens Building utilizes a reinforced concrete frame, which provides significant strength, durability, and resistance to environmental conditions. Reinforced concrete combines high compressive strength from concrete with the tensile strength of embedded steel reinforcement, allowing the structure to safely support heavy loads and large spans typical of lecture theatres. In terms of durability, concrete is highly resistant to rot, pests, and general wear, contributing to a long service life of over 50 years with minimal maintenance. However, environmental exposure can lead to gradual deterioration, particularly through carbonation and moisture ingress, which may cause corrosion of the steel reinforcement if cracks develop. Climatically, the material performs well in the UK's temperate conditions, resisting wind and rain effectively due to its density and mass. Nevertheless, repeated freeze–thaw cycles and temperature fluctuations can cause surface cracking or spalling if the concrete is not properly designed or maintained. Overall, the reinforced concrete frame is well-suited to the building's functional and environmental demands, although ongoing maintenance is essential to preserve its structural integrity over time. The buildings capacity to endure Northern England's climate is shaped by how its concrete mitigates moisture ingress and thermal stresses. Seasonal temperature fluctuations induce thermal stresses that can cause cracking and deformation. Guidance on thermal crack control during early was less comprehensive in mid-20th century codes compared with today's regulations. As using a sufficient concrete cover, water ratio and curing methods result in design

components (columns, beams, and slabs) tackling the northern England weather conditions.

Comparing reinforced concrete structure with potential alternative steel structure

Time

A steel structure s associated with faster construction time compared to the reinforced concrete structure of roger Stehen's building. The reinforced concrete structure requires a longer period of curing which is most important part of the construction process low temperatures slow down the curing of reinforced concrete. The reinforced concrete structure is faster to construct than the steel structure. Steel framing is unaffected by weather conditions while reinforced concrete is.

Labour

The constructing of reinforced concrete structure requires a different investment in labour compared to a steel structure. Concert frame requires higher labour costs due to the complexity of the construction work the unique design of the Roger Stephens Building which includes ventilation pipes and recessed balconies is a result of the complexity of the concrete frame. Prefabricated steel frames involve the use of prefabricated materials and require less skilled labour.

Program

Steel frames offer greater flexibility and adaptability to schedule requirements and long-term use. Concrete frames do not offer the same design flexibility as steel frames. Steel frames can achieve large spans using smaller columns. This has been beneficial for designing branching interior spaces and various lecture halls. The original design for the Roger Stephens Building in 1963 included cantilevered theatres. This design was not implemented due to its high cost. Steel is more suitable for this type of design due to its

high load-bearing capacity and ability to span large distances. Unlike steel frame concrete frame cannot be modified once completed.

Cost

Although concrete is less expensive than steel other costs can be saved by using steel. Concrete is valued for its economy in terms of material and volume however adding certain architectural elements can be costly as demonstrated by the design of the abandoned building. Foundation requirements steel is 50% lighter than concrete. Concrete is much heavier than steel therefor it requires more expensive foundation work. Although steel is an expensive raw material concrete needs periodic coating to ensure its longevity and prevent carbonation.

Ease of Assembly and Adaptation

In terms of ease of assembly, reinforced concrete frames are generally more complex and time-consuming to construct compared to steel framing. The process requires on-site formwork, placement of reinforcement, pouring, and curing, all of which must be carried out in sequence and are highly dependent on-site conditions and weather. This makes assembly slower and less flexible than steel, which benefits from prefabrication and rapid on-site erection using bolted or welded connections. However, concrete does allow for monolithic construction, meaning the structure is cast as a single continuous element, which can improve overall stability and robustness.

Regarding adaptability, reinforced concrete frames are typically less flexible than steel frames when it comes to altering building shape or use over time. Concrete structures often rely on load-bearing walls or rigid column grids, making later modifications such as removing walls, creating new openings, or reconfiguring internal layouts more difficult and costly. In contrast, steel frames usually offer greater flexibility due to wider spans and fewer load-bearing internal elements, allowing easier reconfiguration for different uses. Over the life cycle of the building, this means that a concrete-framed structure like the Roger Stevens Building may be more challenging to adapt to new functions, such as converting lecture spaces into offices or residential use, without significant structural

intervention. Nevertheless, concrete frames can still accommodate some level of change if designed with flexibility in mind, such as incorporating larger spans or non-load-bearing partitions. As a wet form of construction concrete must be managed on site with formwork reinforcement and pouring the assembly of roger stevens building was complex particularly because of its brutalist style which included recessed balconies and internal ramps thereby making labour costs and construction times higher than the prefabricated advantages of steel in addition the development of the structure itself can be constrained by the curing process which is most important factor in gaining strength and which can be impeded by low temperatures.

The adaptability of concrete framing is complex to non-existent although steel framing is intended for adaptability and change of use, the nature of reinforced concrete makes it difficult to alter the framework once established. The lack of functionality has also become apparent in the interior of Roger stevens building.

Services provision and integration

Unlike steel framing where the framework can easily accommodate service installations concrete framing offers fewer opportunities for service integration. Standard concrete design from the period man have not emphasized the importance of service integration simplification. The Roger Stevens building overcame these issues with service integration by making these components a key architectural feature of the building. This is because the buildings aesthetic appeal is largely based on exposed ventilation pipes which integrate the necessary service components with the external brutalist style. This contrasts with concrete designs which may try to hide these components within a fixed framework in case of steel this process can be made easier using easy to cut wiring and plumbing components.

Demolition and end of life challenges

Some concrete structure such as the Roger Stevens building experiences several challenges at the end of its life cycle this is because unlike steel which can be easily demolished and recycled concrete can be difficult to dismantle.

Due to the difficulty in dismantling concrete structure contemporary engineering trends suggest that a historic concrete structure such as Roger Stevens should be refurbished

or upgraded rather than demolished. This is because the building is currently Grade 2 listed.

Unlike steel which can be recycled by melting concrete must be crushed to produce recycled materials from construction waste. At the end of its life cycle, a reinforced concrete frame building presents several challenges in terms of demolition and disposal. One of the primary issues is the sheer strength and mass of reinforced concrete, which makes it difficult and time-consuming to break down. Demolition typically requires heavy machinery such as hydraulic breakers or explosives, increasing cost, noise, dust, and disruption, particularly in dense urban environments like a university campus. Another significant challenge is the separation of materials: concrete is cast around steel reinforcement, making it difficult to efficiently separate and recycle both components. While crushed concrete can be reused as aggregate, the process is energy-intensive and often results in downcycling rather than high-value reuse. Additionally, older buildings may contain hazardous materials (such asbestos in adjacent components), requiring careful removal before demolition can proceed safely. Environmental concerns are also important, as concrete production and disposal are associated with high carbon emissions, meaning demolition contributes further to the building's overall environmental impact.

These challenges can be partially addressed through careful planning and modern demolition techniques. For example, selective or deconstruction methods can be used instead of traditional demolition to allow safer material separation and increased recycling rates. Advanced crushing and sorting technologies help recover steel reinforcement and reuse concrete more effectively. Furthermore, designing buildings with end-of-life considerations in mind such as designing deconstruction or using modular elements can reduce future demolition difficulties. However, for older reinforced concrete structures like the Roger Stevens Building, these strategies were often not fully considered at the time of construction, making demolition more complex and resource intensive.

Conclusion:

To conclude a concrete structure (Roger's stevens building at university of leads) has been chosen to analyse. Moreover, the analyses required has been achieved successfully highlighting the design components being used relative to the challenges being face throughout the construction, lifetime, and demolition phase with respect to the environment and community. In addition, reinforced concrete is extremely strong material to used for brutality functionality and longer life design periods.

Sieve Analysis Problem:

This part of the assignment supplies a particle size distribution obtained from the sieve analysis of an all in aggregate with a mass of 1250g used in concrete production.

Tabel of sieve analysis:

Sieve Size (mm)	Mass(g)	% on sieve	% Passing
125	0	0	100
75	0	0	100
63	0	0	100
37.5	120	9.6	90.4
20	137	10.96	79.44
10	143	11.44	68.00
6.3	105	8.4	59.60
3.35	45	3.6	56.00
2	130	10.4	45.60
1.18	63	5.04	40.56
0.6	105	8.4	32.16
0.3	102	8.16	24.00
0.212	109	8.72	15.28
0.15	98	7.84	7.44
0.063	55	4.4	3.64

Coarse aggregate size being greater than $4.7\ mm$ **and fine aggregate being less than** $4.7\ mm$ **therefore:**

Fine aggregate below $4.7\ mm$ = $56\ \%$. Showing more grounded particle size hence more workability.

Coarse aggregate above = 100 – 56=$44\ \%$. Might results in some crocking due to less grounded particle size.

37.52% below 1.06 mm is found to be medium sand.

49.82% between 1.06 mm and 32.75mm is found to be gravel.3.64% is less than 0.035mm is found to be silt. 9.6% is greater than 32.75 mm is gravel.

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