Construction Roofs Properties and Temperature Transfer between the Roofs

Done by: Eng. Tareq Ibrahim Alnkhailan.

Mechanical Engineer in the Public Authority for Applied Education & Training, Specialized trainer member in the Instate of Civil Structural Training, Kuwait

Assisted by: Eng. Ali Yahya AL Fadhli.

MBA Certified Civil Engineer Projects Manager at Badael Modern Materials Company, Kuwait

Email: Ali.Yahya.Alfadhli@hotmail.com

Abstract:

This study aimed to explore the disadvantages of solid concrete slabs and sandwich panels as roofing structures in the Arabic Gulf area and explore the differences between traditional solid concrete slabs and sandwich panels roofing systems, highlighting the benefits and usage of EPS panels over traditional systems.

The study methodology focuses on scientific analysis of EPS panels' chemical compound and physical characteristics, highlighting their suitability for various construction roofing applications in a tested field.

The study conclude that, the The EPS panels are the better modern era building roofing material construction choice for the roofing panels because of the panels properties and economical values that supress the sandwich panels and the classical solid concrete slabs starting with the EPS panels fast fixing time, Furthermore, being a light wight roofing material that tolls less load on the buildings structure and less pressure on the building man power that results in more work activity per day and less building reinforcement work and cost especially when building extensions in aged buildings, And recommended to not add additional protective waterproofing layer above the EPS roof, in order to close any opening or gaps between joints that may transfer water through the roof layers.

Keywords: Construction, Roofs, Properties, Temperature Transfer

1. Introduction

The main roofing materials used in the construction field in the Arabic gulf area are the reinforced concrete slabs, sandwich panels and the EPS boards. Reinforced concrete slabs are the oldest and most classic roofing type, made from a composite material combining concrete and steel reinforcement. They offer impressive bearing capacity, resistance to wear and tear, and are ideal for long-term structural integrity in buildings, warehouses, and multi-story structures. Concrete also exhibits excellent fire resistance, making it a crucial safety feature. However, Concrete's heavy weight, heat conductivity, and longer curing time can pose challenges for high-rise buildings, requiring additional structural support, affecting construction complexity and cost (Garber, 2006).

The other construction roofing materials are the sandwich panels. Sandwich panels are roofing composite building materials consisting of three layers: two outer aluminium skin layers and a core layer of polyurethane foam and mineral wool. These panels are excellent insulation, trap heat and noise, and are lighter than solid concrete slabs, simplifying construction and reducing time. On the other hand, this study compares the properties of EPS slabs (EPS) with reinforced solid concrete (RSC) and sandwich panels (SB) slabs as a modern material alternative, highlighting the need for structural assessments and proper sealing to ensure the appropriateness of sandwich panels (homsen, 2005)

EPS panels are a lightweight, cost-effective, thermal isolator, sound insulator, and fireproof system made of 6mm fiber cement boards, cement, sand, glass, wood, expanded polystyrene, water, and other materials. The study explore the disadvantages of solid concrete slabs and sandwich panels as roofing structures in the Arabic Gulf area. Solid concrete slabs are heavy, poor thermal and sound insulators, and time-consuming to modify. Sandwich panels, despite their advantages, are limited to heavy loads, fire-resistant, and easy to penetrate, causing moisture accumulation and water infiltration. EPS panels offer solutions to these flaws and other benefits (Equs, 2023)
The study explores the differences between traditional solid concrete slabs and sandwich panels roofing systems, highlighting the benefits and usage of EPS panels over traditional systems.

The study methodology focuses on scientific analysis of EPS panels' chemical compound and physical characteristics, highlighting their suitability for various construction roofing applications in a tested field.

2. The study framework

The study farmwork will demonstrate the function and aids of using the EPS panels as an alternative roofing system to the solid concrete slabs and sandwich panels system supported by lab tests and practical filed experiments

The study farmwork can be summarized in the following bullet points:

1- The EPS panels roofing system building time.
2- The EPS panels weigh.
3- The EPS panels bearing load
4- The EPS panels Thermal insulation properties
5- The EPS panels water and moister isolation properties
6- The EPS panels sound insolation properties.
7- The EPS panels fire resistance properties.

2.1. The EPS panels roofing system building time.

The EPS panels roofing system are fast to fix and build due to the panels light weight characteristics. In addition, to the EPS panels simple method of fixing that requires only to tile the panels and apply adhesives in between each panel only. For 100 m2 building time is less than a single working day the same time required for fixing 100m2 building time for the sandwich panels roofing system. However, the building time for 100m2 concrete solid slab will take not less than a week that includes 2 working day for carpentry works, 1 working day for steel reinforcement works, 1 working day for concrete pouring and 3 working days for water curing which add up to a total of 7 days.

The following table demonstrate the building time for building 100m2 roof surface of EPS panels in comparison with the sandwich panels and solid concrete slab.

Table (1-1) Systems building time requirements.

Roofing system	Time required to build (days)
EPS panels (1)	1
Sandwich panels (2)	1
Solid concrete slabs (3)	7

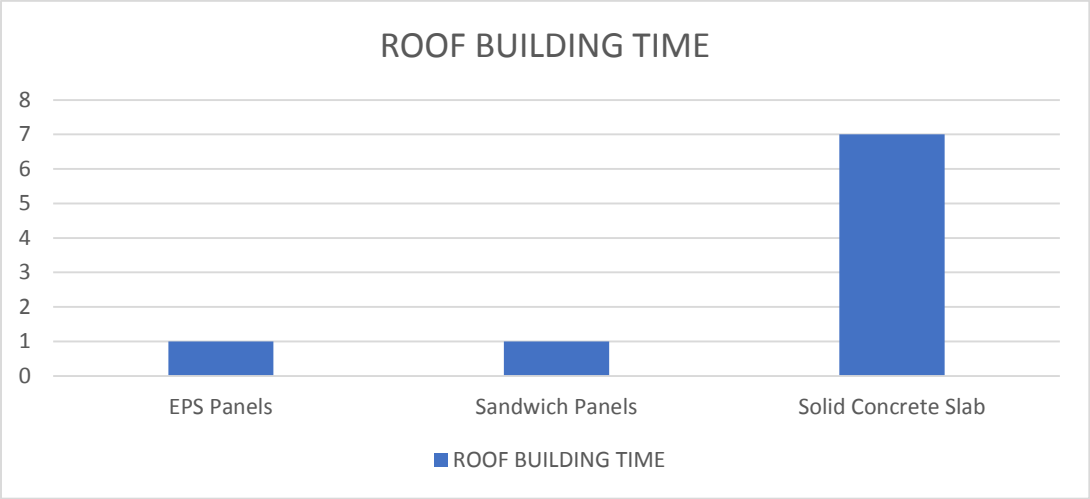


Chart 1-1: Roof building time comparison time.

2.2. The EPS panels weigh

The EPS panels considered a light weight material which make them a perfect choice for over aged building extensions and an economical tool to reduce the cost of the supporting building structure materials and reinforcement unlike the solid slab concrete which consider a heavy roofing structure. The following table clarify the EPS panels weight in comparison with the solid concrete slabs and sandwich panels, each panel weight for 1 square meter surface.

Table (2-1) Systems weight per 1 square meter surface.

Roofing system	**Weight kg/m2**
EPS panels (1)	63
Solid concrete slabs (2)	240
Sandwich panels (3)	20

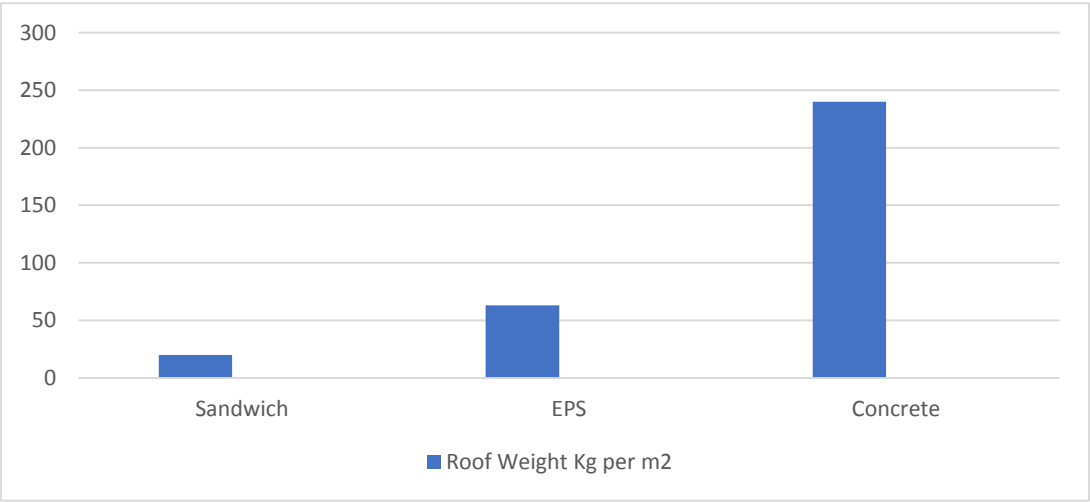


Chart 2-1: Roof Weight Kg/m2

2.3. The EPS panels bearing load

The EPS panels have a high bearing load capacity equivalent to the solid concrete slabs, which make the EPS a safe choice for residential building and heavy loads service buildings such as hospitals, hotels, malls and airports, unlike the sandwich panels which consider a low duty roofing materials for heavy loads bearing.

The following table clarify the EPS panels load capacity in comparison with the solid concrete slabs and sandwich panels, each panel weight for 1 square meter surface.

Table (3-1) Systems load bearing capacity per 1 square meter surface.

Roofing system	Weight KN/m2
EPS panels (1)	10
Solid concrete slabs (2)	10.5
Sandwich panels (3)	4

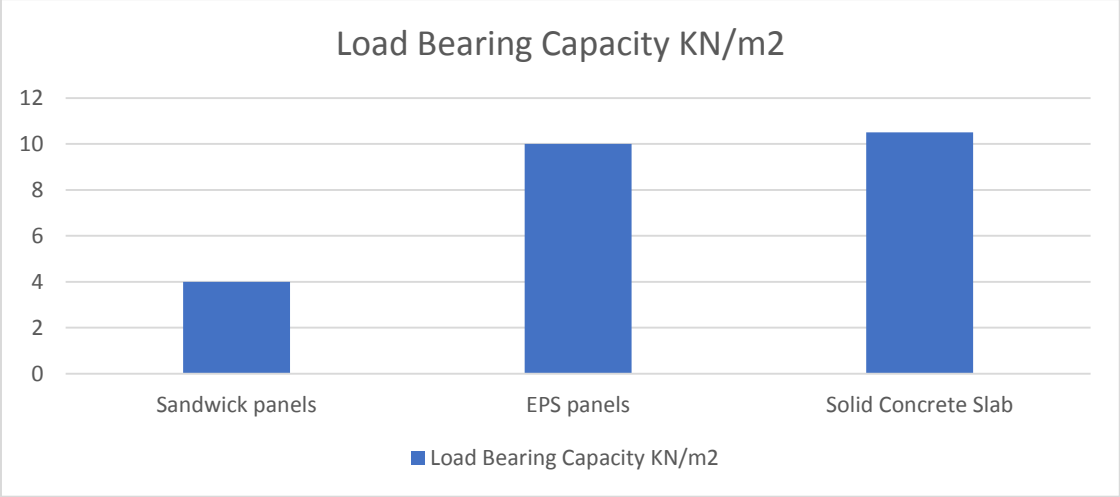


Chart 3-1: Roof Panels Load Bearing Capacity KN/m2

2.4. The EPS panels Thermal insulation properties

The EPS panels consider a great thermal insolation roofing material which has a greater thermal insulation property than the sandwich panels and the solid concrete slabs, which comes with economical values in which can be useful in reducing the energy and electricity required to conserve temperature. In addition, the EPS panels thermal insulation properties aid in reducing the loads on air conditioning machines which lead to further extension of the machines operating age.

The following table clarify the EPS panels thermal insulation properties in comparison with the solid concrete slabs and sandwich panels, each panel sample of 1 square meter surface.

Table (4-1) Systems thermal insulation properties per 1 square meter surface.

Roofing system	Thermal Transmission W/m2K
EPS panels (1)	0.57
Solid concrete slabs (2)	10
Sandwich panels (3)	2

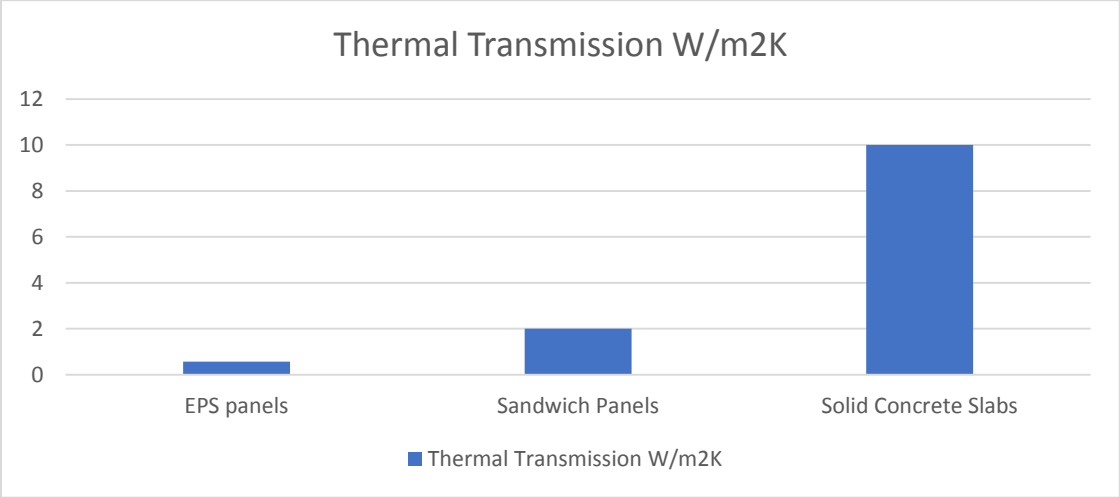


Chart 4-1 Roofing Panels Thermal Transmission W/m2K

2.5. The EPS panels water and moister isolation properties

The EPS panels is a perfect water and moister proof roofing material in which it can be used to be a roof for wet areas such as toilets and swimming pool. Moreover, the EPS panels require less extra water proofing application to be applied over The EPS roof, just a thin layer to be fully protected from the panels edge.

The following table displays the EPS panels water absorption percentage after 24hours water submerging test and in comparison, with the solid concrete slabs and sandwich panels, each panel sample of 15 square centimetres cube.

Table (5-1) Systems water absorption percentage per 1 square meter surface.

Roofing system	Water absorption %
EPS panels (1)	2.5
Solid concrete slabs (2)	75
Sandwich panels (3)	7

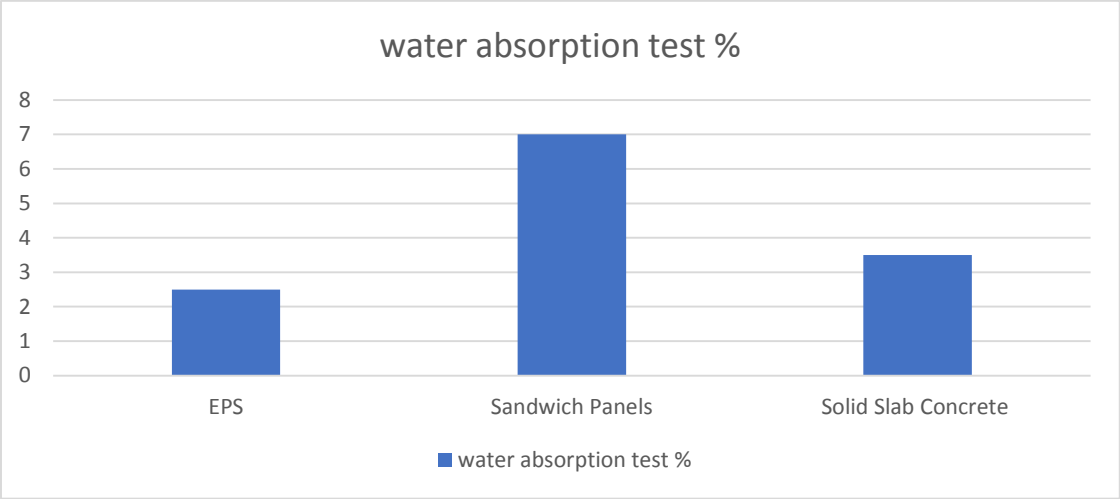


Chart 5-1 Roofing Panels Water Absorption test%

2.6. The EPS panels sound insolation properties.

The EPS panels is ideal sound insolation roofing materials. The EPS panels has a superior acoustic property than the sandwich panels and solid concrete slab, which make them the top choice for comfort homes, hotels, clinics, library or study area and hospitals. The following table displays the EPS panels sound insolation acoustic properties and in comparison, with the solid concrete slabs and sandwich panels, each panel of 1 square meter surface.

Table (6-1) Systems sound insolation acoustic properties per 1 square meter surface.

Roofing system	Sound Accoustic dB
EPS panels (1)	37
Solid concrete slabs (2)	20
Sandwich panels (3)	25

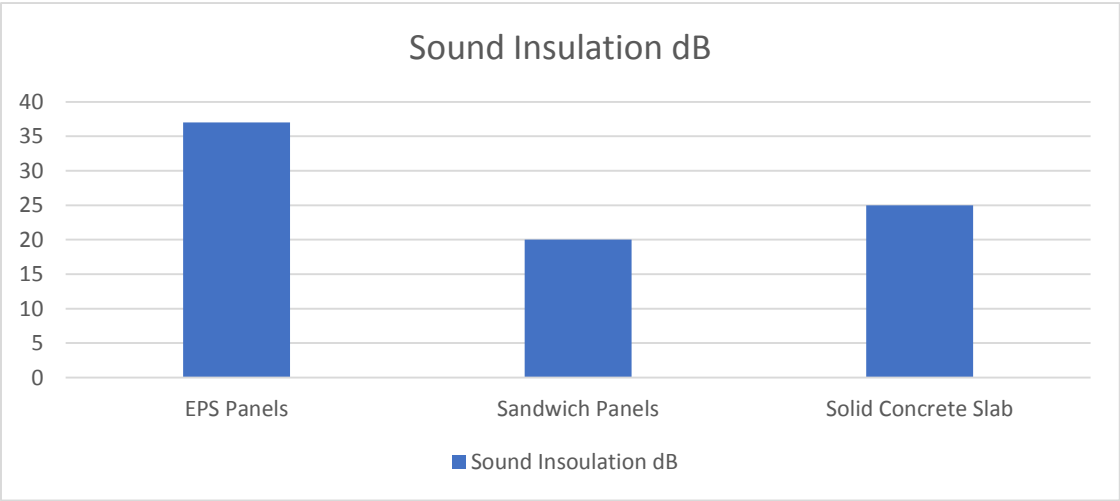


Chart 6-1: Roofing Panels Sound Insulation dB

2.7. The EPS panels fire resistance properties.

The EPS panels have greater fire resistance capability than the sandwich panels and the solid concrete slab, in which considered a safe roofing option for high heat areas such as kitchens, restaurants and factories.

The following table portraits the EPS panels fire resistance rate and in comparison, with the solid concrete slabs and sandwich panels, each panel weight for 1 square meter surface.

Table (7-1) Systems fire resistance rate per 1 square meter surface.

Roofing system	Fire Resistance Rate (hrs)
EPS panels (1)	2.5
Solid concrete slabs (2)	0.75
Sandwich panels (3)	1.5

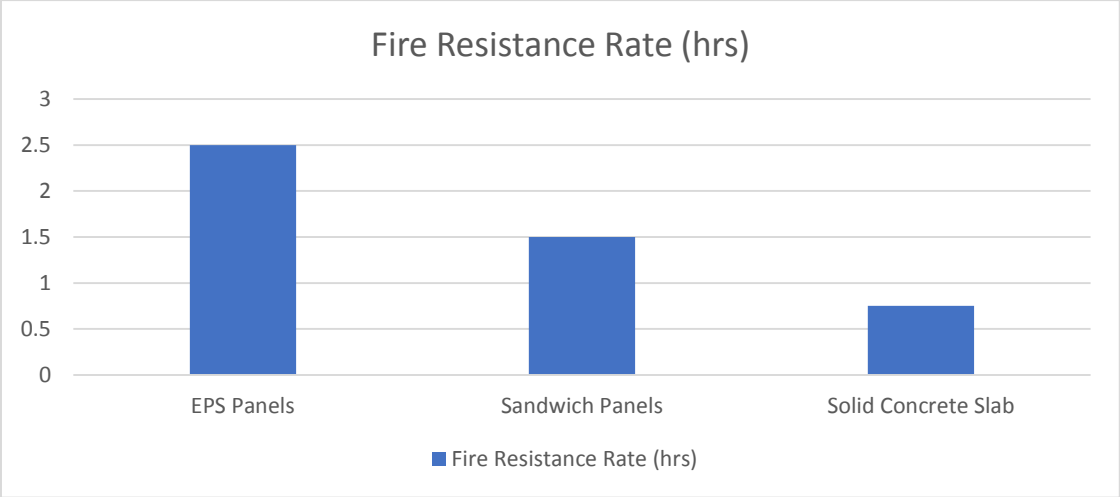


Chart 7-1: Roofing Panels Fire Resistance Rate (hrs)

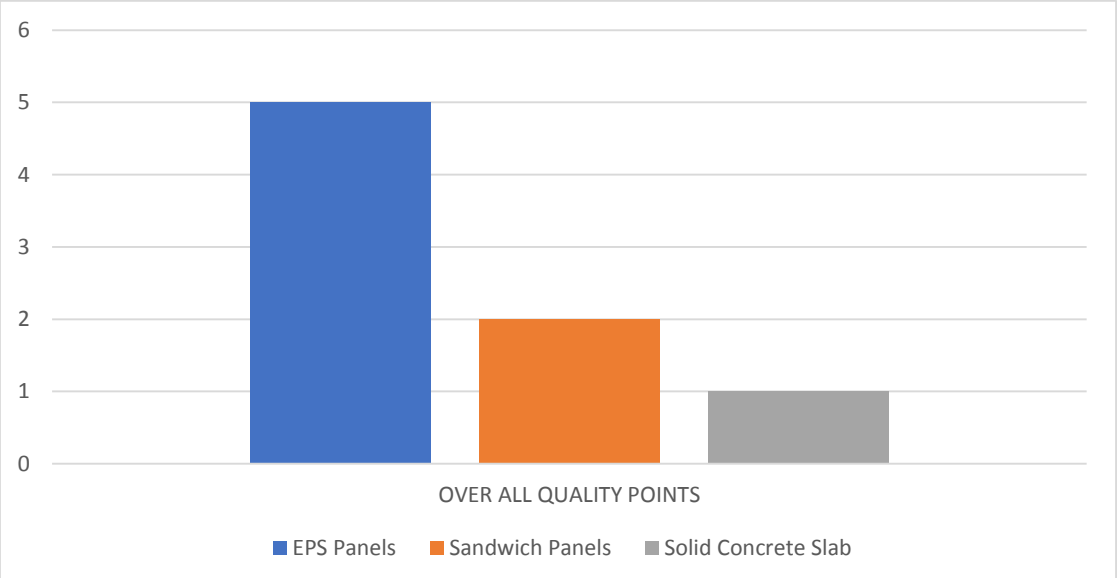
3. The study results and discussing

The above results shows that the EPS Panels are fast and simple roofing materials to fix that requires only tiling the panels, then add the adhesive agent. In addition, the data in table (2-1) indicate that the EPS Panels are lighter than the solid concrete slabs by approximate 74% but have a relative same load bearing capacity as the solid concrete slab as shown in the date displayed in table (3-1). Moreover, as shown in table (4-1) the EPS temperature insulation ability is more than 3 time the ability of the sandwich panels and more than 20 times the abilities of the solid concrete slab. Additionally, as indicated in table (5-1) the EPS panels are better water resistance material than the sandwich panels twice the time and better than the solid concrete slab by more than 30

times. Furthermore, the EPS panels can isolate sounds better that their peers as been displayed in table (6-1) acoustic test that resulted the EPS sample with 37 dB units in compare with the sandwich panel and solid concrete that resulted in 20dB & 25dB. Last but not least, the EPS panels can resist fire more than the sandwich panels and solid concrete slab as demonstrated in table (1-7) 500C oven test results that shows the EPS panels ability to withstand fire for 150 minutes which is twice the time of the sandwich panels and solid concrete slab that resulted 90 minutes and 45 minutes respectively. The study results for the EPS panels superior quality comparison points can be summarized in the following table and chart.

Summary table.

Blocks type	EPS Panels	Sandwich Panels	Solid Concrete slab
Quality Point			
Building time	1	1	
Lighter Surfess Mass		1	
Greatest bearing load capacity			1
Best thermal insulator	1		
Best water isolator And moisture resistance	1		
Best sound insulator	1		
Best fire resistance	1		
Overall quality points	5	2	1



Summary Chart overall quality points Compression Chart.

4. The study conclusion

The EPS panels are the better modern era building roofing material construction choice for the roofing panels because of the panels properties and economical values that supress the sandwich panels and the classical solid concrete slabs starting with the EPS panels fast fixing time, Furthermore, being a light wight roofing material that tolls less load on the buildings structure and less pressure on the building man power that results in more work activity per day and less building reinforcement work and cost especially when building extensions in aged buildings. Moreover, the EPS panels are better roofing material choice for wet areas due to its superior water and moister resistance properties. Additionally, EPS panels offers effective sound isolation as they can reduce the sound intensity passing through the roofs by 37dB, make it better chose for comfort in quite places like residential buildings and hospitals. Add to that, EPS panels have afire resistance ability to stand active fire up to 150 minutes, which make the EPS panels safe materials for construction locations and kitchen areas.

5. The study recommendations

It is not recommended to add additional protective water proofing layer above the EPS roof, in order to close any opening or gaps between joints that may transfer water through the roof layers. Additionally, the EPS panels should be supported and jointed by the adhesive powder, after mixing with water and wait for the adhesive for a day at lest to get the adhesive to be effective. Moreover, the EPS panels should be cut using the mechanical saw only to avoid damaging the EPS interior component.

6. References

(1), 2021. Building With L.W. Panels.. *lightweight building factory.*.

(3), Cavanaugh, K., (2002). *Guide to Thermal Properties of Concrete and Masonry Systems: Reported by ACI Committee 122. American Concrete Institute.*. s.l.:s.n.

Equs, H., (2023). *EPS Panels: definition, types, benefits & applications.* s.l.:s.n.

Garber, G., (2006). *Design and Construction of Concrete Floors. 2nd ed.*. s.l.:s.n.

homsen, O., (2005). *Sandwich structures 7: advancing with sandwich structures and materials.* s.l.:s.n.

(2), Lamilux, (2024). *Quality guidelines for sandwich panels,* s.l.: s.n.

Doi: doi.org/10.52132/Ajrsp.e.2024.59.3