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Filler Slab as a Substitute to Customary Roofing Mechanism

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Abstract: *Lightweight structural components called filler slabs are utilised in building construction, particularly for roofing applications. Contrary to traditional solid slabs, filler slabs use non-structural fillers in the lowest part of the slab, such as lightweight aggregates or waste materials. While preserving structural integrity and load-bearing capability, this design maximises the use of concrete. The investigation of alternative technologies has been prompted by the rising need for eco-friendly and affordable roofing solutions. A possible method for building roofs that are both inexpensive and environmentally friendly is the filler slab, which is one such invention. As an alternativeto conventional roofing technology, infill slabs are described in this abstract.*
Key Words: *Filler slab, Alternative construction techniques, Cost efficient, Thermal performance, Material efficiency*

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I. Introduction

In order to minimise the weight of a structure without sacrificing its elasticity, filler slabs are a production technique used in structures. It involves constructing a slab with hollow spaces or fillers, as well as light materials or air gaps, between the concrete layers. The slab becomes lighter and more cost-effective because to this design's reduced use of concrete. Filler slabs come with many advantages. Second, the slab's hollow spaces can be used for utilities like electrical and plumbing installations, eliminating the need for additional conduits and pipes. Additionally, the areas as a whole provide thermal insulation, assisting in maintaining a pleasant indoor temperature and decreasing the need for excessive cooling or heating. Typically, dead load and live load are supported by slabs in buildings. When concrete and steel are used together to make RCC blocks, fillerslab technology is nothing more than an alter native to R.C.C. slab. This is due to each material's unique limitations and properties as a distinct building material. In a conventional rcc slab, a lot of concrete is wasted and is required for reinforcement because of the added load o f the concrete, which could otherwise be replaced by inexpensive and lightweight filler materials. As a result, the l ower tensile region of the slab does not require any concrete other than to hold the steel reinforcements together.

Due to the usage of 40% less steel and 30% less concrete, both the dead weight and the cost of the slab will be reduced to 25%.

II. Need for alternatives

In India, the construction industry is responsible for a significant portion of the energy intake and a significant portion of the CO2 emissions (22% of total emissions) [3].
Technology that is sustainable is necessary to lessen the negative impact.
Using this technology, a sizable percentage of the concrete in the tension zone is removed and replaced with a thin, affordable filler that is inert and lightweight. This specific technology not only decrease the cost of the materials but will also lessen carbon emissions by using less energy-intensive materials. The overall result is a 30% reduction in carbon emissions [4].

III. Filler material selection

The selection of filler materials is based on the following factors:

1. The substance must be non-reactive and inert in nature.
2. Because concrete's hydration is affected, a restriction on water absorption must be put in place.
3. If a structure is lightweight, the overall weight of the structure will be reduced.
4. It ought to be affordable in comparison to the cost of replacing the concrete.
5. The size and thickness of the material must conform to the slab's dimensions and reinforcing spacing.
6. Aesthetic considerations must be made to avoid the ceiling having unappealing faces.

IV. Materials used

It is necessary that the filler substance be inert. It shouldn't react with the concrete or steel in an RCC slab. Filler material has to be light in weight to reduce the slab's overall weight and the strain on the foundations.

The cost of the filler substance ought to be significantly lower than the cost of the concrete it is meant to replace.This is essential for achieving economy.

Depending on its thickness, filler material should have dimensions and a cross section that can fit into the spacingbetween the reinforcement and the slab.

To avoid producing an ugly ceiling pattern, the texture of the filler material should be mixed to suit the necessary ceiling finish criteria.

Fig. Use of clay pots as a filler material.

V. Methodology

1. Structural Design: The structural requirements and load-bearing capabilities of the building are the basis for the filler slab's design.
The right design parameters must be decided after consulting with a structural engineer.
2. Formwork Preparation: To give the filler slab strength and shape, formwork is produced.
Usually, steel or wooden formwork is employed, and it must be securely erected and positioned in accordance withthe design requirements.
3. Reinforcement Bar Placement Reinforcement bars, such as steel rebars, are inserted into the formwork to increase the filling slab's strength and stability.
The rebar spacing and arrangement should follow the design specifications.
4. Filler Material Placement: Filler material is poured or inserted between the formwork and reinforcement. It may take the form of lightweight aggregates like expanded clay or polystyrene pellets.By reducing the slab's overall weight while retaining its structural integrity, this filler material.
5. Concrete Pouring: Following the placement of the filler material, concrete is poured over it.
For good consolidation and bonding, the concrete needs to be mixed with the right amounts of aggregate and at theright consistency.To ensure a uniform mixture and remove air gaps, vibrators may be utilised.
6. Finishing: Following the pour and levelling of the concrete, finishing operations are completed.
Typically, this entails sanding the surface smooth, scraping off extra concrete, and applying curing agents or membranes to promote adequate hydration and avoid premature drying.
7. Curing: Proper curing is necessary to encourage the development of concrete strength and prevent cracking.
By covering it with wet burlap, plastic sheets, or curing chemicals, the filler slab should be kept moist and shieldedfrom quick moisture loss.
8. Formwork removal: After the concrete has developed enough strength, the formwork can be taken off.
To guarantee the stability of the slab, it is crucial to adhere to the suggested curing time indicated by the structuralengineer.

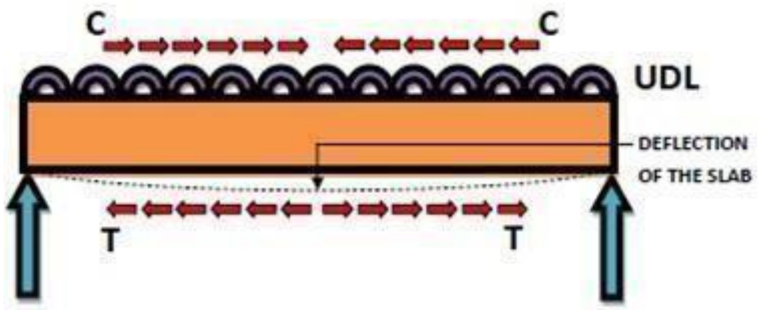

Figure 1. Simply supported slab cross section

Knowing this much if we want to move further to understand the ―Filler slab‖ technology, we will have to further study the cross section of a typical simply supported RCC Slab. Under its own load and applied load, the slab will try to bend as shown in the Figure 1.

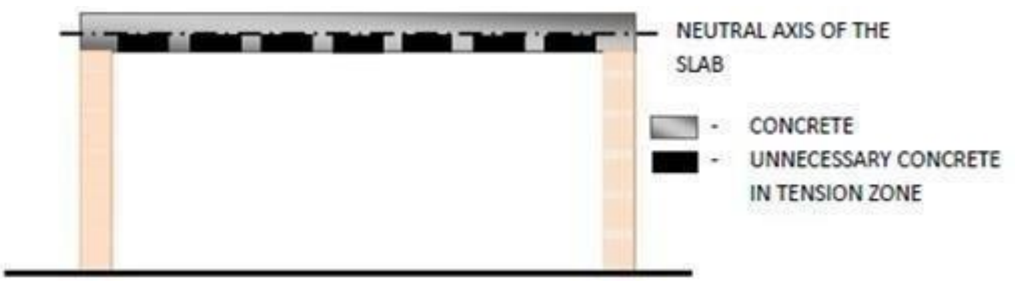

Figure2. Showing unwanted tension concrete

Referring to Figure 2, we can see that the top fibres of the slab will be in compression, while the bottom fibres are in tension, showing the neutral axis and tension concrete, respectively. Understanding filler slab technology requires having this knowledge. In a slab, compression is on the top fibre while the bottom fibre is under tension. As a result, the tension zone, where concrete is not as necessary, can be removed if we wish to optimise the construction. This is the secret of filler slab building. This roofing system is incredibly cost-effective. Since it is difficult to remove the concrete from the tension zone due to the way the slab is built on site (in relation to Gujarat), we attempt to partially replace; that part of concrete using light weight and low cost filler material. This method of construction is called fillerslab.All over India, filler slab technology is in use, but Ar. Laurie Baker did a significant amount of the effecti ve promotion and transmission of this technique in South India.

It is one location where filler slab has moved beyond study and controlled implementation to become one of the co mmon construction options by both the public and private sector, and also architects and designers have been advo cating this technology. These filler components are positioned without compromising the structural strength, stability, or durability in order to replace unwanted and ineffective tension concrete. Consequently, the slab's dead weight is reduced and expensive energy materials are not consumed, saving money in the process. In addition to cost and energy savings, a cavity can be created internally between the filler material to improve the interiors' thermal comfort. Another benefit is that less dead weight is carried from the foundation to the supporting pieces, which further reduces the cost of designing these components. These filler materials are positioned so as not to jeopardise the structural strength, stability, and durability. As a result, unwanted and nonfunctional tension concrete is replaced from below, saving money by reducing the consumption of high-energy materials and the dead load on the slab.

Advantages of filler slab technology-

1) You may save roughly 19% of the overall concrete cost by using RCC filler slab construction rather than an RCC solid (traditional) slab when Pune tiles are used as filler material. If you include the cost of filler material, you can save an additional 5–10% of your concrete cost.

2) Another benefit is that you can save around 15% on the cost of building a roof out of concrete if the filler materialis just garbage, such as temporary Pune panels that are taken off the roof to build a pukka roof.

3) In order to save money and reduce the use of materials with a high energy consumption, filler slab technology can also be used in township and mass housing projects. Another advantage can be of a better thermal comfort if a cavity is kept between the filler material or the filler material itself has a cavity. For example tow Pune tiles/Clay tiles can be kept one over the other to form an air cavity thus keeping the interiors of your house remain cooler in summer and warmer in winters.

4) Filler slabs can be left uncovered (with correct workmanship) to produce a ceiling with a view of the filler materialfrom below, saving money on plastering and/or painting.

5) Cement, steel, sand, and aggregates are the main ingredients in RCC, which is a particularly energy-intensive material. Thus, this method is now included in the list of environmentally friendly and sustainable technologies and corporate green building features due to the reduction in concrete required compared to standard slab construction.

Design Parameters

Although a filler slab can be constructed similarly to a normal RCC slab, the filler material is responsible for the decrease in dead load, hence it is important to take reinforcement spacing into account according to the size of the filler material. Filler material shouldn't be any thicker than the neutral axis' depth. The filler material depth shouldn't go over 60mm for a 125mm slab thickness. The filler material's size and shape should correspond to the requirements of the design. The kind and dimensions of the filler material determine how much concrete needs to be replaced in the tension zone. A minimum of 25% of the concrete should be poured without difficulty or concern for form costs. There are a number of design factors to consider when filler slabs are being thought about as a replacement for conventional roofing technology

Design and Durability

The 2005 building code of India states that the filler slab is permissible and that it complies with the provisions of pertinent laws pertaining to material, style, and construction, and therefore, manner. The work given is for the intended use. The Authority may approve any alternative, including Ferro cement construction, row-lock (rat trap) bonds in masonry, stretcher bonds in filler slabs, and filler slabs, as long as it is determined that the planned alternative is satisfactory and complies with all applicable provisions relating to material, style, and construction, and that the material, method, or work offered is, for the intended purpose, at least equivalent to that specified within the Code in quality, strength, and compatibility. Defeat, sturdiness, and security. Important construction steps for filler slab are as mentioned below.

The filler material to be used must be waste materials or materials which are locally available and lighter than concrete.As with a typical RCC slab, the slab shuttering is carried out.

When erecting the shuttering that forms a grid, a minimum bottom cover of 15mm is maintained, and filler materia l will be positioned centrally in each grid gap.Bands of concrete at the edge of the slab don't have any filler materia Those concrete bands have a minimum width of 300mm.These bands have a smaller reinforcement spacing than th e filler material spacing.After all of the filler materials have been laid out, any hidden work, etc., should be inserted into the spaces between the filler materials. Next, concrete is poured over the filler materials to achieve the desired slab thickness.This study makes use of a number of materials, including cement (53 Grade), M-sand, coarse aggregate, and reinforcement steel. The only thing M-sand is is smashed granite boulders into smaller bits. Its size is between coarser than silt and finer than coarse aggregate. Due to its higher cost than river sand, M-sand is frequently employed as a substitute. Gravel stones larger than Msand in size make up coarse aggregate. These are often produced by shattering granite rocks into smaller pieces. The size that should be employed in concrete should typically range from 10 to 20mm. Hot round bars made of reinforcement steel are given deformation patterns to improve the bond between the steel and concrete. Tensile strength is added to concrete by using this steel.

VI. Cost analysis of slab

1. Material savings: Filler slabs replace a portion of the concrete volume with lightweight materials like filler blocks or expanded polystyrene (EPS) sheets. As a result, less concrete is used overall, saving money on materials.
2. Shorter Construction Time: Compared to traditional slabs, filler slabs may be built more quickly because they require fewer cycles of pouring and curing concrete. This may result in lower labour costs and quicker project turnaround times, both of which have positive financial effects.
3. Lower Dead Load: Filler slabs assist reduce the dead load on the foundation and other structural components by lightening the weight of the building. By enabling a lighter foundation design, this might potentially result in cost savings.
4. Energy Efficiency: Compared to regular slabs, filler slabs offer superior thermal insulation, which can result in energy savings while cooling or heating the building. Given the potential for lower energy use, this component mayresult in long-term cost savings.

Comparison cost of Conventional slab and Filler slab	Conventional slab (2m x 2m)	Filler slab (2m x 2m)
Volume of concrete (m^3)	0.6	0.4848
Cement required (kg)	229.9	185.7
Fine aggregate required (kg)	405.8	327.9
Coarse aggregate required (kg)	667.2	539
Cost of cement for concrete	Rs 2299	Rs 1857
Cost of Fine aggregate for concrete	Rs 259.7	Rs 209.9
Cost of coarse aggregate for concrete	Rs 400.3	Rs 323.4
Cost of shuttering	Rs 2000	Rs 2000
Weight of steel (kg)	12.64	12.64
Cost of steel	Rs 632	Rs 632
Cement required of filler material (kg)	-	36.3
Cost of cement for filler material	-	Rs 363
Total cost	Rs 5591	Rs 5385
10% over head	Rs 559.1	Rs 538.5
Final cost	Rs 6150.1	Rs 5923.5

Fig. Cost Comparison Table.

On calculating the amount of concrete, the amount of steel, the cost for shuttering and the cement required for the making of filler material, cost analysis was done in comparison with the conventional slab as shown in table 5 and it was observed that the total cost required to construct conventional slab was Rs.6150 and the cost required to construct filler slab was Rs 5923.

VII. Result.

(REBOUND HAMMER TEST ON FILLER SLAB.)

Sr No	ID Mark	Dat e of Casting	Grade of Concret e	Rebound (Number) e	Hamm			Readings	Dista -nce(mm)	Time in (us)	Pulse Velocity in (Km/Sec)
1	TOP C-20BSW	30/ 01/ 23	M 40	37	24	28	36	28	300	74.6	4.02
				28	30	28	26	26			
2	M C-20BSW	30/ 01/ 23	M 40	26	34	33	32	30	300	75.6	3.97
				36	30	36	30	28			
3	Below C-20BSW	31/ 01/ 23	M 40	22	24	22	20	22	300	86.4	3.47
				22	30	22	22	20			
4	TOP C-18SW	27/ 01/ 23	M 40	26	32	26	24	26	300	73.4	-
				24	24	24	26	28			
5	M C-18SW	27/ 01/ 23	M 40	26	26	28	26	25	300	84.1	3.57
				30	24	27	26	24			
6	B C-18SW	27/ 01/ 23	M 40	23	30	24	26	34	300	78.9	3.80
				30	28	32	34	28			
7	T C-21SW	27/ 01/ 23	M 40	33	34	36	36	28	300	75.8	3.96
				30	32	32	30	28			
8	B C-21SW	27/ 01/ 23	M 40	38	32	33	36	40	300	74.6	4.0
				32	32	38	34	30			
9		27/	M 40	32	30	28	28	36	300	72.6	4.13
	M C-21SW	01/ 23		28	28	30	30	30			

10	T C-15SW	26/ 01/ 23	M 40	36	30	30	28	28	300	81.9	3.66
				40	32	30	26	32			
11	M C-15SW	26/ 01/ 23	M 40	30	30	30	34	30	300	79.3	3.78
				28	34	30	28	32			
12	B	26/	M 40	27	27	26	32	30	300	78.4	3.83

	C-15SW	01/23		32	34	28	28	28			
13	T	30/01/23	M 40	30	36	28	30	30	300	79.1	3.79
	C-20ASW			34	28	28	26	28			
14	M	30/01/23	M 40	38	26	26	28	26	300	76.8	3.91
	C20ASW			26	30	28	30	30			
15	B	30/01/23	M 40	34	32	28	32	34	300	74.3	4.04
	C-20ASW			36	36	30	36	30			
16	T	30/01/23	M 40	30	34	30	34	30	400	115.2	3.47
	C-46SW			30	32	30	30	30			
17	M	30/01/23	M 40	34	34	28	30	32	400	119.4	3.35
	C-46SW			28	34	32	30	32			
18	B	30/01/23	M 40	34	30	30	38	30	400	111.9	3.58
	C-46SW			30	30	34	34	30			
19	T	29/01/23	M 40	30	40	34	32	40	300	89.9	3.33
	C-08SW			32	30	42	34	36			
20	M	29/01/23	M 40	34	26	32	34	36	300	83.4	3.59
	C-08SW			34	30	36	36	44			
21	B	29/01/23	M 40	30	34	36	32	30	300	85.4	3.53
	C-08SW			38	34	30	34	34			

VIII. Conclusions

In conclusion, filler slabs may, in certain cases, be a good substitute for conventional roofing techniques. In order to decrease the quantity of concrete and steel needed for construction, filler slabs are lightweight constructions that use filler materials like clay pots, tiles, or polystyrene blocks. In addition to lowering expenses, this improves the building's energy effectiveness. Improved thermal insulation, less dead load on the structure, and enhanced cost effectiveness are just a few benefits of using filler slabs. By maintaining cosy interior temperatures, they can lessen the need for a lot of air cooling or heating. Additionally, filler slabs' smaller weight reduces stress on the building's base and saves the cost of materials and transportation during construction. However, it's necessary to take into account a few infill slabs' limits. As they have a somewhat lesser resistance to water seepage and wind uplift forces, they might not be appropriate for locations with strong rainfall or wind speeds. Additionally, to guarantee the structural integrity and endurance of filler slab roofs, suitable technical design and construction practises are essential. In the end, the choice to employ filler slabs as an alternative to conventional roofing technology is determined by elements including the local environment, financial restraints, and the particular needs of the project. It is advised to get the advice of a certified structural engineer or architect to ascertain the viability and appropriateness of filler slabs in a particular situation.

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