

REPORTS AT A GLANCE

of

TESTS CONDUCTED TO FIND MATERIAL PROPERTIES AND BEHAVIOUR & RESISTANCE TO EARTHQUAKE CONDITIONS

of

GYPCRETE BUILDING PANELS

by

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and

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TESTS BY STRUCTURAL ENGINEERING RESEARCH CENTRE (SERC)

Material properties / behaviour / performance

| | | | |
|---------------------------------------------------------------------------------------------------------|---|----------------------------|------------------------------|
| 1. Compressive Strength without infill | : | 7.31 N/mm ² | 73.1 Kg/cm ² |
| 2. Compressive Strength with concrete (M20) infill | : | 18.07 N/mm ² | 180.7 Kg/cm ² |
| 3. Flexural Strength by single point load without infill | : | 2.13 N/mm ² | 21.3 Kg/cm ² |
| 4. Flexural Strength by single point load with concrete M20 infill | : | 2.08 N/mm ² | 20.8 Kg/cm ² |
| 5. Flexural Strength by double point load without infill | : | 3.80 N/mm ² | 38.0 Kg/cm ² |
| 6. Flexural Strength by double point load with concrete M20 infill | : | 4.59 N/mm ² | 45.9 Kg/cm ² |
| 7. Axial Compression of wall panel 2.85m height x 2m width x 120mm thick without infill | : | 281.70 kN (140.85 kN/m) | 28.17 tons (14.09 tons/m) |
| 8. Axial Compression of wall panel 2.85m height x 0.775m width x 120mm thick with concrete (M20) infill | : | 1200 kN (1548.3 kN/m) | 120 tons 154.83 tons/m |
| 9. Ductility Factor of Gypcrete empty panel | : | 4.11 | |

10. EARTHQUAKE RESISTANCE :

All the 6 structures / buildings / houses tested **withstood the artificial earthquake with a maximum peak ground acceleration of 0.36g satisfying the requirement of IS-1893 (Part – I) 2002 for Zone – V**. This is equivalent to earthquake intensity of Richter Scale 8.

TESTS BY INDIAN INSTITUTE OF TECHNOLOGY (IIT) MADRAS

11. Water Absorption : 1.97% (when immersed in water for 24 hours)
12. Rain Water Penetration : 0.57% (when subjected to simulated rain beating)
13. Compressive Strength of panel filled with FaL-G cement concrete : 11.00 N/mm² (110.0 Kg/cm²)
14. Fire resistance : The panel had a Fire Rating of 4 hours for a temperature range of 700 °C to 1000 °C.
15. Durability :
 - a) Wetting and drying test : No reduction in compression strength after 20 cycles of wetting and drying.
 - b) Corrosion test : Found no corrosion effect on steel reinforcing rod embedded with concrete filled in the cavities of the panel, when subjected to severe marine environment (Non-Corrosive)
16. Impact Test : Gypcrete building panel has high resistance against impact. Impact resistance tremendously improved by infilling the panel with cement concrete / FaL-G cement concrete.
17. Nailing and Pull Out Test : Nailing and pull out test proved that nailing and screwing can be done on the wall panel even without any infill to carry the normal weight expected to come on the nails and screws due to household utilities, pipe lines and electrical wirings, cloth drying ropes etc.
18. Sound Transmission Class (STC) : Sound Transmission Test without infill found that Gypcrete panel belongs to a class of STC 40 with respect to airborne sound insulation.
19. Young's Modulus : 0.15×10^5 N/mm² (1.5×10^5 Kg/sq.cm)
20. Poissons Ratio : 0.15 to 0.23
21.
 - a) Net density of empty panel : 1.139 gm/cc (1139 Kg / m³)
 - b) Gross density of empty panel : 0.405 gm/cc (405 Kg / m³)
 - c) Density of the panel with concrete (M20) infill : 1.74 gm/cc (1740 Kg / m³)

KEY RECOMMENDATIONS BY SERC & IIT MADRAS:

- 1) From various tests carried out by SERC and Indian Institute of Technology (IIT) Madras, it can be seen that the Gypcrete building panels can be used for construction of houses / buildings up to **two storeys with out infill** and up to **six storeys with infilling by concrete / FaL-G cement concrete** and appropriate structural design.
- 2) It can also be used to construct **high rise buildings more than 6 storeys** with infill concrete and steel reinforcement and proper structural design. (It is found that load carrying capacity of infilled panels per meter width was about 11 times that that of panel without infill.)
- 3) The light weight (weight density of 405 Kg/Cu.m) of Gypcrete panels is **ideal for use as infill panels in framed construction** leading to considerable economy in the members of the frame – beams and columns and foundations as compared to infill with conventional brick masonry.
- 4) From the tests it is also evident that the structures can withstand earthquake with intensity of Richter Scale 8 (0.36g) with proper structural design details. Thus the material provides an opportunity for people to construct earthquake resistant structures at competitive cost.
- 5) Use of concrete with FaL-G as cement instead of OPC can be an economic alternative.
- 6) Water resistant and corrosion resistant characteristics of the Gypcrete panel will enable to use for construction of houses / buildings even in high intensity rainfall areas as well as in severe marine environment.
- 7) Use of panels results in speeding up of building construction which is very much relevant to our Country in order to clear the huge backlog of housing shortage.

Conclusion and recommendation by SERC :

“ The performance of the Gypcrete building panel as a building material has been evaluated under static and dynamic (seismic) condition meeting the requirements of IS-1893 (Part-1) 2002 for Zone –V with 5% damping case and for soil strata condition. Seismic intensity and ground acceleration (g) specified for various seismic zones as per IS-1893 (Part-1) 2002 are the following :

| Seismic Zone | II | III | IV | V |
|---------------------|-------|------------|--------|-------------|
| Seismic intensity | Low | Moderation | Severe | Very Severe |
| Ground Acceleration | 0.10g | 0.16g | 0.24g | 0.36g |

Other related tests are also carried out and the results are as follows :

1. The static compressive strength is found to be 7.31 MPa.
2. The flexural capacity of the Gypcrete panel has increased up to 40% with in-fill.
3. The concrete in-fill has improved the axial load carrying capacity for a wall panel of size 2800 x 775 x 125mm to 1200 kN (120 tons), whereas empty panel (775mm long) without in-fill carried an axial load of 290 kN (29 tons).
4. All the six housing models were subjected to an artificial earthquake, meeting the requirement of IS –1893 (Part-1) 2002 for Zone – V with 5% damping case and for soil strata condition
5. All the six model houses withstood a maximum peak ground acceleration of 0.36g (200% design response spectrum equivalent to Maximum Credible Earthquake) given at the base on the shake table satisfying the provisions of IS-1893 (Part-1) 2002 for Zone-V.

Based on the above study, it is found that Gypcrete building panel is suitable for use in seismic resistant houses / buildings with two stories in seismic Zone –V, ie. Very severe earthquake intensity in Indian conditions. The results given in this report can be used for extrapolating to stories higher than two, considering the effects of flexibility, natural period, damping co-efficient, elastic modulus (Young’s modulus), additional mass effect and non-linearity. Proper design of steel reinforcement and cement concrete as per the structural design requirement is to be incorporated for multi-storied buildings. Also when the panel is used for walling and roofing or for any intermediate floor, seismic safety provisions are to be incorporated by providing suitable reinforcement for multi-storied buildings. ”

Assessment and recommendations by IIT Madras :

- a) The light weight (weight density of 405 Kg/Cu.m) of Gypcrete panels makes them ideal for use as infill panels in framed construction leading to considerable economy in the members of the frame – beams and columns and foundations as compared to infill with conventional brick masonry.
- b) The compressive strength of Gypcrete panels is found to be around 2.7 MPa, on the gross area. This strength is adequate for the panels to be used in load bearing masonry up to two floors. This is in view of the very low self weight of the panels themselves and also the absence of mortar joints. In case of higher number of floors (more than two floors), the cavities require to be filled (grouted) with concrete suitably. Use of concrete with FaL-G as cement instead of OPC can be an economic alternative.

Compressive strength of Gypcrete panels filled with such concrete was found to be around 11.0 MPa, which is adequate for up to 5 to 6 floors of load bearing construction. If higher strengths are required for high rise building construction or where high concentrated loads come on Gypcrete wall panels, reinforcement can be introduced along with concrete infill. The introduction of reinforcement in wall panels for buildings with more than two storeys can also be advantageously used to resist lateral forces due to wind, earthquake etc...

- c) Being light, the panel sizes can be large that can result in some economy in bedding mortar. Use of large panels results in speeding up of construction. The latter aspect is very much relevant to our country in order to clear the huge backlog of housing shortage. The limitation in this respect may be the handling / lifting / erection of these large panels.
- d) The Gypcrete panels exhibited a water absorption of about 2 percent whereas the permissible water absorption for best quality bricks is 10 percent.
- e) The rain penetration test has clearly demonstrated the Gypcrete panels are not affected by even high intensity rains. As such, they can be used for external cladding / walling of high-rise buildings and also in constructions at places of high rainfall.
- f) The two durability tests, viz. wetting and drying, salt spray (corrosion) test, though carried out for relatively smaller length of time, clearly showed the superior quality of Gypcrete panels with respect to their long term performance.
- g) The impact test has demonstrated the resilience of the material against impact. The observed behaviour of Gypcrete panels is mainly due to the presence of fibres in the skin of the panels.
- h) The pull out loads recorded indicate that nailing and screwing can be done on the panels. These nails / screws can be used to suspend any weight or for fixing pipe lines or electrical wiring without damaging the panels.
- i) Fire resistance test proved that the Gypcrete building panel is a material with 4 hour fire rating and can withstand temperatures in the range of 700°C to 1000 °C. ”