Critical Examination on R. C. Vacated Slab and Conservative R.C.C. Slab Parametric Study

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Abstract- *The Bubble Level slab is a newly planned bi-axial concrete floor slab system. High density polythene (HDPE) hollow spheres are placed in the center of slab by changing the ineffective concrete to decrease its dead weight so increase the efficiency of floor. This abstract deal with work carried out to compare the bubble level voided slab system and conventional flat slab system by finite element study using SAP 2000 as well as manual calculation by Direct design method using IS456:2000 to study the performance of bending moments, shear force, deflections and responses due to change in span for various load situations. The current study is carried out to study the seismic performance of structure due to decrease in dead weight of structure by modelling and analysis of G+12 floor structure for 6mx 7m, 7m x 8m, 8mx 9m grid systems.*

Keywords- Bubble level Vacated Slab, SAP2000, Shear Force, Bending Moment

I. INTRODUCTION

The Bubble Level slab is a revolutionary biaxial concrete floor system developed in Europe in1990's by Jorgen Breuning. The traditional Bubble Level technology uses spheres made of recycled industrial plastic to create air voids while providing strength through arch action. This results in a dramatic reduction of dead weight by as much as 35-40% allowing much longer spans and a smaller amount supporting structure than traditional solutions. Hence, the Bubble Level has many advantages as compare to traditional concrete slab such as lowered total cost, reduced material use, enhanced structural efficiency, decreased construction time and is a green technology. It gains much of attention from engineers and researchers from the world. But, while designing a reinforced concrete structure, a primary design limitation is the span of the slab between columns. Designing large spans between columns often requires the use of support beams or varies thick slabs thereby increasing the weight of the structure by requiring the use of large amounts of material. Weightier structures are less desirable than lighter structures in seismically active regions because a larger dead load for a building increases the magnitude of inertia forces the structure must resist as large dead load contributes to higher seismic weight. Incorporating support beams can also contribute to larger floor-to- floor heights which subsequently increases costs for finish materials and cladding. A new solution to reduce the weight of concrete structures and increase the spans of two-way reinforced concrete slab arrangements was developed in the 1990s in Europe and is gaining popularity and acceptance worldwide. Plastic voided slabs deliver similar load carrying capacity to traditional flat plate concrete slabs but weigh significantly less. This weight reduction makes many benefits that should be considered by engineers determining the structural system of the building. Plastic voided slabs eliminate concrete from non-critical areas and replace the removed concrete with hollow plastic void formers while completing similar load capacity as solid slabs.

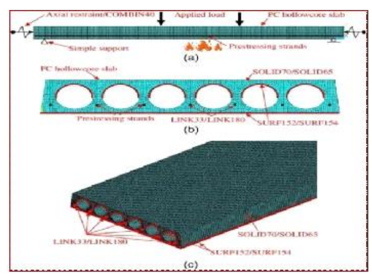


Fig 1.1:Voided slab BarPlacement

Fig 1.2 :Voided slab ConnectionwithConcreteBeam

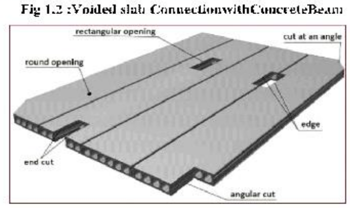


Fig1.3:Voided slabwithOpenings

II. LITERATURE REVIEW

Ihsan A. Al-Shaarbaf 1, Adel A. Al- Azzawi 2&RadhwanAbdulsattar 3, 2018, this paper is based on literature reviews related to previous research and studies on HCS. Based on the past researches this paper suggests it is feasible to use HCS one way slab as a roofing member for buildings. The NSM-CFRP strengthening method majorly supports the bending and shear load capacity of pre stress HCS. The reduction in shear span to depth ratio for solid slab causes larger flexural strength by about 29.06% and ultimate deflection by about 17.79%. There is a reduction in cross sectional area extends between 29% to 35% for block slabs, which ultimately leads to reduction in weight of the HCS compared to conventional slabs i.e. RCC slab. In this paper the authors have discussed on various advantages of Voided slab slab and process to design the Voided slab slab.

Some of the advantages of Voided slab slab discussed in this paper are:

- It decreases the total dead load of the building
- It reduces construction cost and time.
- Immediate un-propped working platform.
- Extra-long spans.
- Factory produced to rigorous quality standards The process of designing Voided Slab:

The design method for a Voided Slab floor system would naturally contain the subsequent conditions:

Prateek Ghosh, 2016, in this study comparison has been done between RCC and steel framed structures using Voided slab concrete slabs as utility. The study concludes that precast concrete constructions are very common in low earthquake regions as they are cost effective, quick to assemble and build. Have lower self weight, use fewer raw materials. Widely used in India, Europe, USA and Canada.

This paper is based on a case study of project "Shankaracharya Medical College and Hospital Building" situated at Junwani, Chhattisgarh. The project consists of a G+5 building to be used as hospital and a G+4 building for medical college. In this the author has discussed about the specification of Voided slab slabs used in the mentioned project. The target for the completion of the project was estimated to be 24 months but if it was to constructed using the conventional method i.e., RCC then it was estimated to be 36 months. Due to the time limitation it was decided to construct a steel framed structure along with pre-cast pre stressed hollow-core concrete slabs for roofs and floor. All the Voided slab slabs were 150 mm thick, 1.20m wide, and 6.00 m long. The slabs was pre stress using 9 mm diameter, 1770 MPa low relaxation, seven-wire strands.

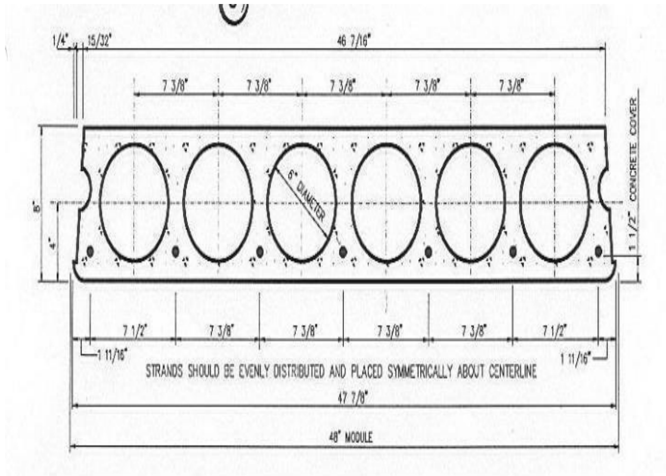


Fig 2.1 : Voided slab Slab Detail

L.J. Woods[1], D.K. Bull[2] and R.C. Fenwick[3], 2008, this paper is based on performance of HCS under gravity loads. Paper includes the importance of negative bending moments in HCS and conditions how it is exposed to the (-) bending moments. Paper gives what should be included in HCS slab design to avoid failures due to shear and flexure in negative bending moment regions.

Negative Bending Moment in Voided slab Floors:

Negative moments can be formed in Voided slab floors by number of mechanism such as when continuity has been established by using reinforced concrete topping. Some of the important actions are:

- Sway of the tall building, due to wind or seismic actions, which creates relative rotation between the support and voided units;
- Vertical earthquake ground motion, which induces upward and downward seismic forces on the floor;
- Lenthing of beams parallel to the voided units, which pushes the supporting beams apart. This induces tension in the starter bars connecting the topping concrete and voided units to the supports. This action induces axial tension or negative moments in the floor.

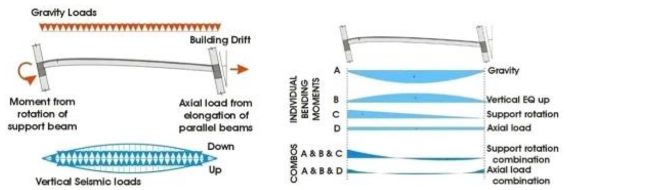


Fig 2.2 : Loads Contributing to moment.

Fig 2.3 : Bending moments from negative bending potential loads acting

Failure modes possible when Voided slab Floors are subjected to Negative Bending Moments:

Fig 2.4 : Hollow-core floor subjected to earthquake drift under upward vertical earthquake motion

Fig 2.5 : Hollow-core floor subjected to earthquake drift under downward vertical earthquake motion

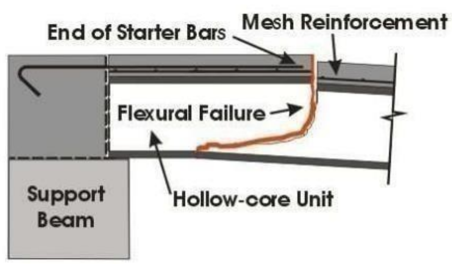


Fig 2.6 : Flexural failure when mesh reinforcement ruptures at the end of starter bars

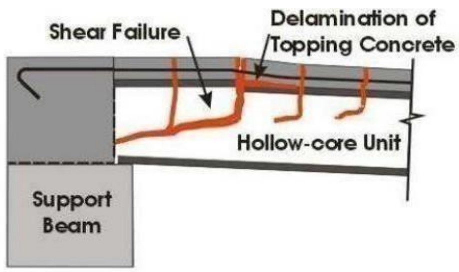


Fig 2.7 : Flexure-shear failure induced by change in tension force in steel between flexural cracks

K.Soundhirarajan[1], M. Raghupathi[2], R. Ragupathi[3], K.Sathish kumar[4], V. Suresh kumar[5], 2018, this paper is based on study of structural behavior of HCS. The study concludes that Hollow core slab are most widely known for providing economical, efficient floor and roof system. HCS provides the efficiency of a precast member for load capacity, span range and deflection control. It also suggests that the top surface of HCS can be prepared by installing non-structural fill concretes ranging from 15-50mm thick depending on type of material used or by casting a composite structural concrete topping.

K.M. Monisha[1], G. Srinivasan[2], 2017, this paper is based on comparative investigation on structural behavior of HCS and RC slabs. Study suggests that cost efficiency of pre stress Voided slab slab is high.

Load carrying capacity of RCC slab is 20% less when compared to pre stress Voided slab.

Prasad Bhamare[1], Sagar Bhosale[2], Akshay Ghanwat[3], Shubham Gore[4], Sheetal Jadhv[5], Sachin Patil[6], 2017, this paper concludes the design of precast members is economical if proper care is taken while designing. The cost and time duration of traditional construction is high when compared to precast construction. Better concrete quality can be achieved with lighter concrete units.

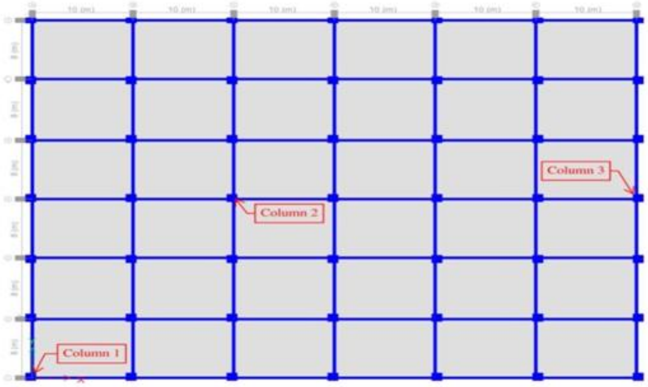
III. METHODOLOGY

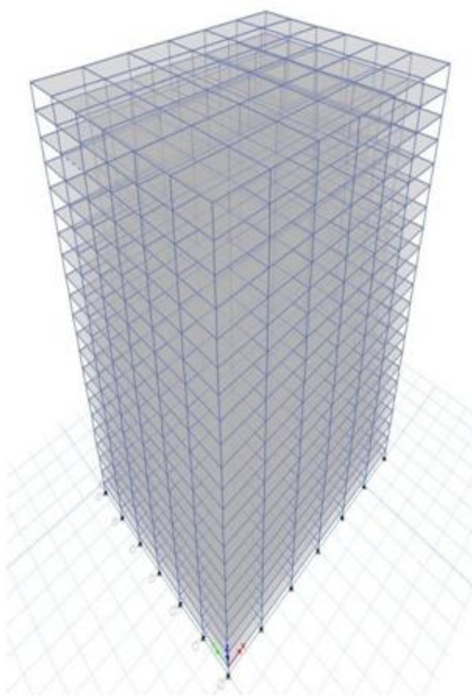
The proposed work is planned to be carried out in the following manner

- Study of seismic analysis method. Study of clauses related to design of RC structure from following codes:
  - IS 456:2000
  - IS 1893:2016
  - IS 13920:2016
  - IS 875 Part 1,2 and 3.
- Selection of building G+21
- Analysis of columns, beams, floor and footing using ETABS.
- Comparing the RC structural behavior of column, beams, floor and footing on following parameters:

  Column: Shear, Moment, Axial forces.
  - Floor: Displacement, floor Shear.
  - Footing: Base Shear

ETAB MODEL





BUILDING SPECIFICATIONS

S.No	Case I	Case II
1.	Slab type: RCC slab	Slab type: Hollow core slab
2.	Storey: G+21	Storey: G+21
3.	Plan Dimension: 60m x 48m	Plan Dimension: 60m x 48m
4.	Height of each storey: 3.5m	Height of each storey: 3.5m
5.	Column Size: 750mm x 750mm	Column Size: 750mm x 750mm
6.	Beam Size: 300mm x 700mm	Beam Size: 300mm x 700mm
7.	4 model each for Zone II, III, IV and V.	4 model each for Zone II, III, IV and V.
8.	Building is fairly symmetric in plan and elevation.	Building is fairly symmetric in plan and elevation.
9.	Soil Condition: Medium Soil	Soil Condition: Medium Soil
10.	Importance Factor: 1	Importance Factor: 1
11.	Response Reduction: 5	Response Reduction: 5
12.	Assume Slab Thickness: 300mm Calculation (d) = (L/35) Slab Dead Load = 7.5 kN/ m^2	Assume Slab Thickness: 300mm Calculation (d) = (L/35) Slab Dead Load = Reduced by 33% = 5.025 kN/m^2
13.	Live Load: a) On Roof: 1.5 kN/m^2 b) On Floor: 3 kN/m^2	Live Load: a) On Roof: 1.5 kN/m^2 b) On Floor: 3 kN/m^2
14.	Floor Finish: 1 kN/m^2	Floor Finish: 1 kN/m^2
15.	Material: M 40 Grade concrete & Fe 500 Reinforcement	Material: M 40 Grade concrete & Fe 500 Reinforcement
16.	Unit Weight: Concrete- 25 kN/cum	Unit Weight: Concrete- 25 kN/cum

ANALYSIS AND COMPARISON OF RESULTS

AXIALFORCE (COLUMN)

The maximum axial forces in the 3 columns in longitudinal and transverse direction is considered for examine in seismic zone II, III, IV and V for case I and case II:

Graph: Axial force.xlsx

- Axial force on all the three columns is longitudinal and transverse direction is less for case II compared to case I for every floor.
- On comparing Axial force reduction in % wise following points can be observed:
- For column 1 the reduction in axial force in case II is between 14% to 18.5% compared to case I and can be seen in all 4 Seismic zones.
- For column 2 the reduction in axial force in case II is between 17% to 22% compare to case I in all four Seismic zones.
- For column 3 the reduction in axial force in case II is between 14% to 20% compared to case I for zone II, III and IV and for zone V the reduction is between 12% to 20%.

SHEAR FORCE (COLUMN)

The maximum shear forces in the three columns in longitudinal and transverse direction is considered for examine in seismic zone II, III, IV and V for case I and case II:

Graph: Shear Force V2.xlsx
Shear Force V3.xlsx

- On observing the data shear force in X and Y direction for case II is less than case I, valid for all seismic zones.
- There will be reduction in Area of steel (Ast) for case II as shear force is directly proportional to Area of Steel hence the structure will be economic.
- It can be observed that the reduction of shear force percentage wise is between 18% to 22% for case II compared to case I.

BENDING MOMENT (COLUMN)

The maximum Bending Moment in the 3 columns in longitudinal and transverse direction is considered for examine in seismic zone II, III, IV and V for case I and case II:

Graph: Bending moment M2.xlsx
Bending moment M3.xlsx

- On observing the data bending moment in X and Y direction for case II is less than case I, valid for all seismic zones.
- There will be reduction in Area of steel (Ast) for case II as bending moment is directly proportional to Area of steel (Ast) and hence the structure will be economic
- It can be observed that the reduction of bending moment percentage wise is between 17% to 21% for case II compared to case I.

DISPLACEMENT (FLOOR)

Plots of floor level displacement in longitudinal or transverse versus height are made for the two cases, all imposed on same graph:

Graph: Displacement-floor.xlsx

- From the graph it is observed that for case II displacement of floor in X & Y direction is less compared to case I, zone wise.
- As the zone changes from II to V, the value of displacement increases for both cases, but Case II displacement remains less from case I in every earthquake zone.
- Floor level in X & Y direction, displacement of case II is around 20% less for every floor when compared to case I in each zone.

STOREY SHEAR (FLOOR)

Plots of shear in story in longitudinal or transverse versus height are made for the two cases, all imposed on same graph.

Graph: Floor shear-Floor.xlsx

- From the graph it is observed that for case II floor shear in X & Y direction is less compared to case I, zone wise.
- As the height of building increases the reduction value of floor shear in case II goes on increasing compared to case I.
- Considering each zone the reduction in floor shear percentage wise for case II is from 19% (ground floor) to 23% (terrace) compared to case I.
- The reduction of floor shear percentage wise for case II compared to case I is constant if we compare zone wise.

IV. CONCLUSION

1) The procedure accepted for the modelling of the vacated flat plate slab, that is by substitution of stiffness decrease factor and improved self-weight of the vacated flat slab is acceptable because, the effects of reaction are same for reinforced concrete vacated and solid flat plate slab systems.
2) For all the cases of the vacated flat slab, the results for deflection is almost same as compared to that of solid flat slabs beneath same loading and at the same point. Therefore, by applying the stiffness reduction factor, we can obtain the deflection of the vacated flat slab same as solid flat slab.
3) Same as deflection, results of moment is also observed for many cases of voided and solid flat plat slabs. From the results, it may conclude that, due to reduced self-weight of the voided flat plate slab, the moment of the slabs is reduced from 7 to 10 % of the solid flat slab at the same point under same loading state.
4) It is determined that using voided flat slab system the base shear of structure is reduced by 12 to 14 % due to reduced material weight

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