Development of IOS Application for Design of Precast Hollow Core Slab and Wall Panel

Thirumalesha E[1], Mr. Manjunatha L[2], Ritesh L[3], Niranjan R Patil[4]

[1,3,4] PG Student Department of Civil Engineering, SJB Institute of Technology, Bengaluru, Karnataka, India
[2]Assistant Professor, Department of Civil Engineering, SJB Institute of Technology, Bengaluru, India

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Abstract - *Construction industry is having large economic importance envisages a speedy development in its technology, which is required in order to keep up its growth pace. Precast technology is progressively seen as an economic and high quality option. The present economic growth demands faster construction without project delay and losing quality aspects. The design of precast Hollow core slab and wall panel is lengthy and time consuming and complex process. The design of hollow core slabs play an important role and require more calculations. In present time use of application is increasing day by day and person to person. In this work, the design and checks for precast Hollow core slab and Wall panel is carried out by developing an IOS application. The design loads and moments are obtained by analysing residential building by using ETABS software.*

***Key Words*: Precast, Hollow Core Slab, Wall Panels, IOS Application, X-code.**

1. INTRODUCTION

Precast construction is one in which the structural component are manufactured in a place away from the building site and are brought to site for their assembling. The distance travelled from the casting site may only be a few meters, it can be plant-cast or site-cast. These individual components are manufactured by industrial methods based on mass production in order to build a large number of buildings at a low cost in short time, Making the system more feasible. Its most dramatic benefit will be speed with which it can be designed, cast, delivered and erected.

1.1 Precast Hollow Core Slab

A Hollow core slab is a precast, prestressed concrete member consisting of continuous voids extending the full length of the slab. Precast slabs are extensively used in prefabricated buildings as floor or roof deck system and also have the applications in spandrel members, wall panels and bridge deck units. Structurally, a hollow core slab provides the efficiency of a prestressed member. The natural diaphragm action available in the cast - in-situ slabs for resisting lateral loads can also be emulated with proper connection details among adjacent components. As far as the slab is concerned, the flexural properties like bending moment and deflection are more important. The structure has to be experimentally analysed whether it can withstand the design load within the permissible deflection limit.

1.2 Precast Wall panel

They may be either prestressed or conventional reinforced and they are manufactured either as cast off-site concrete panel walling, known as precast walls or cast on-site concrete panel know as tilt-up wall panels.

1.3 Status of precast construction in India

Indian construction industry is presently growing in a rapid phase and this growth can be directly related to surge in population. To support the needs for the present population in terms of infrastructure like housing and other amenities, the current in-situ construction practice takes a prolonged time. Hence there is a great need to shift to other construction practices in which the time and cost can be reduced. According to GOI reports current housing deficit in urban India is approximately 18.78 million houses. In this deficit 95% belongs to economically weaker sections (EWS) and lower income group (LIG). It is estimated that actual figures might be in the range of 40 million houses based on studies conducted by various private agencies. In order to provide housing for all by 2022 under (PMAY) scheme we need to construct 9400 million sqft in 6 years (2016 to 2022) as per GOI reports. It means 1600 million sqft every year on an average basis. This deficit is approximately in 200 urban centers which needs 8 million sqft of construction every year in each urban centre on an average basis.

1.4 Growing importance of Mobile applications in daily life

The world is humming to the tune of mobile application where there is a solution for anything and everywhere. A mobile application is a software designed and developed to run on smartphones like iPhone, tablets and other mobile devices basically developed by computer programming. Over the years smartphones have transformed into an operative tool that has become the focal point of many business due to its amazing new and versatile features. Presently these application have become an integral part of our lives and we depend on them in more than one way. Almost everyone have smartphone in present days, so the smartphones are the best way to access solution for all difficulties and a result making life better. Presently the use of mobile apps can be seen in many areas such as education, communication, banking, social media, shopping and many more. Over 20,000 of applications are added to apple app store every month. It could be said that it helps towards some sort of maintaining organized life, due to this there has been increase in new app developers.

1.5 X-code and Swift Programming Language

Xcode is Apple's IDE (Integrated Development Environment), which is used to create IOS applications. The word "integrated" refers that X-code brings together several different tools into a single application. Xcode provide an elegant, powerful User Interface for creating, testing, debugging and managing software development projects on MAC platform. Swift programing language used for writing and developing IOS apps. Swift is a brand new programming language built by apple on a modern compiler infrastructure (low level virtual machine) for IOS, MacOS, tvOS, and Linux. Therefore it allows you to write software for phones safely but strict code. Swift looks and feels like a modern scripting language making it a real pleasure to work with.

2. ANALYSIS OF STRUCTURE CONSIDERED

A model have been developed and different loadings have been applied i.e. DL, LL, seismic loads and their combinations as defined by the IS codes. The model is analyzed and the variation of different forces in the wall from each storey has been studied in the model.

2.1 Analysis of Structure

The building is residential apartment located near Devanahalli, Bengaluru. The city lies in EQ zone II and falls under moderate exposure condition. The multi-storey large panel construction system consists of G+9 floors. It consists of two 2BHK flats in each floor level. Area of each flat is about 35 sq.m as shown in Fig 2.1. The analysis of the structure is carried out using ETABS software. 3D frames are considered and analyzed for dead load, live load, earthquake load along with their combinations.

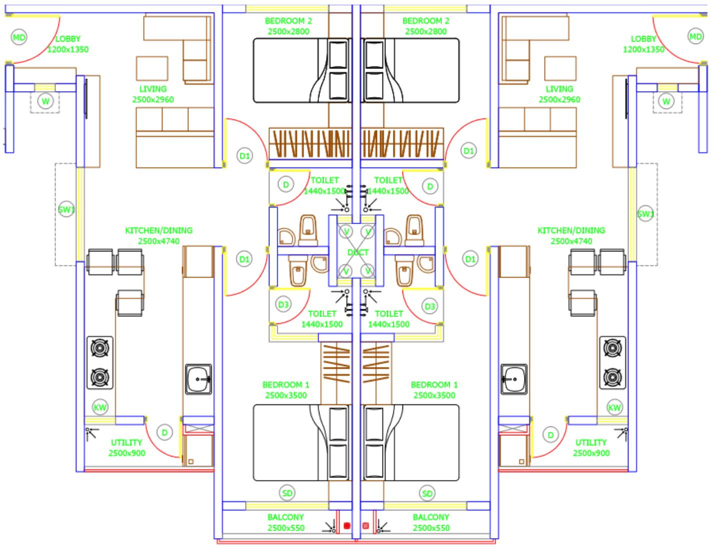


Fig 2.1: Plan of the building

2.2 Loads considered

A) Dead Load: Dead Load is computed considering density of reinforced concrete as 25 kN/m^3 in accordance with IS 875 (Part 1):1987 [11]
B) Live Loads: Live load is taken as
2 kN/m^2 in accordance to the IS 875 (Part2):1987 [12]
C) Seismic load parameters considered as per IS: 1893-2016 (Part 1) are:

Zone factor, Z = 0.10
Importance factor, I = 1
Response reduction factor, R = 3

2.3 Structural Analysis

The wall is designed considering M40 concrete and Fe-415 steel. Wall thickness considered is 160mm and defined as shell-thin element. Whereas slab thickness is 150mm and assigned as a membrane element. Storey height is 3m. Openings in the walls due to doors and windows are incorporated manually by dividing the shell in the required manner. Walls have been automatically meshed to a maximum mesh size of 1m and Slabs are also meshed using default meshing option in ETABS. Each wall is assigned with a pier label individually to make exact identification and also for extracting results easily. The edge moment and torsion have been released independently for each wall to make the wall to wall connection as pinned connection, so that only axial loads are accounted for the design of walls. Fig 2.2 shows the 3D model of the residential building.

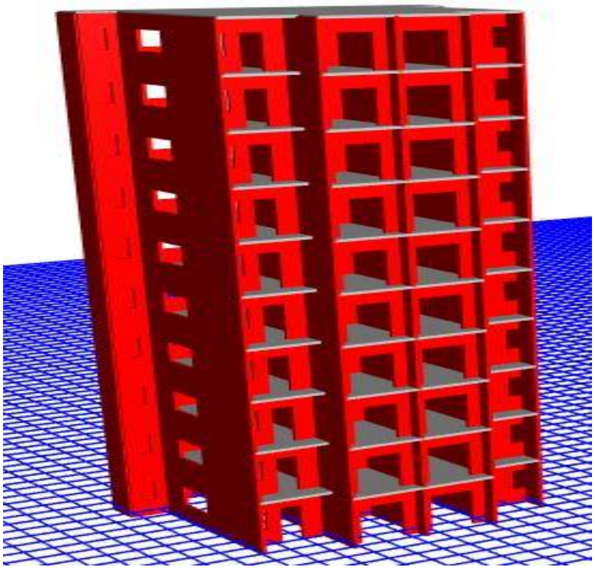
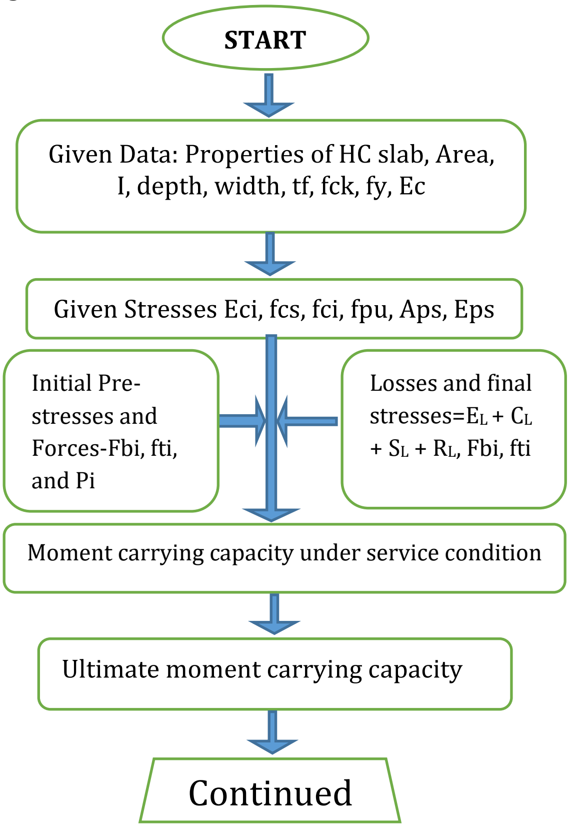


Fig 2.2: 3D model of residential building

3. APP DEVELOPMENT

Development of IOS application using X-code tool in OSX software and writing program for Design of precast hollow core slab and wall panel on Swift programming language. To develop a program, flow chart plays a vital role and it is graphical representation of step by step procedure to do the program.



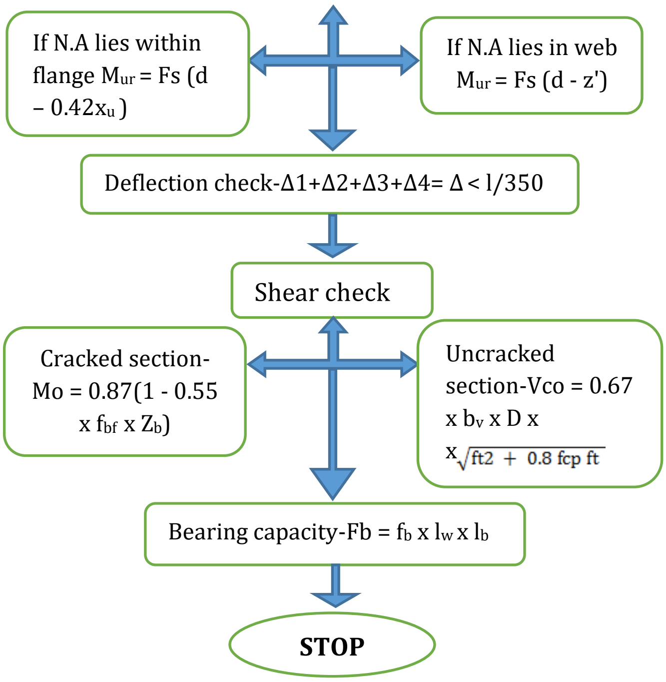


Fig 2.3 Flow chart of developed program for HC Slab

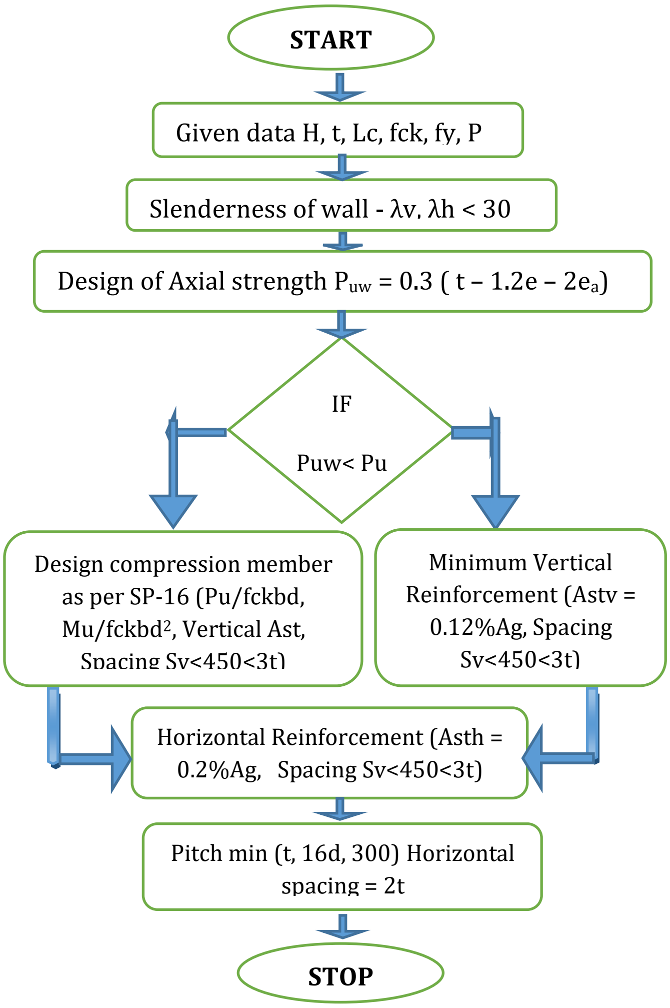


Fig 2.3 Flow chart of developed program for Wall Panel

3.1 Development of IOS Application

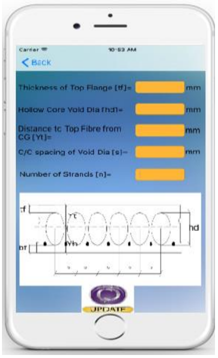
GUI are the visual elements that explores how an application looks and interacts with the user. The GUI acts as a blue print for the development of application and also help-full for future up-gradation. The GUI is mainly focused on the presentation of mobile app. Some of the elements responds to the user interactions such as buttons, text fields and also other informative such as label, images. GUI mainly involves.

1. User analysis (what is that the user wants with the screen)
2. System prototyping (developing a basic frame of the system)
3. Interface evaluation (experimenting with the frame work)

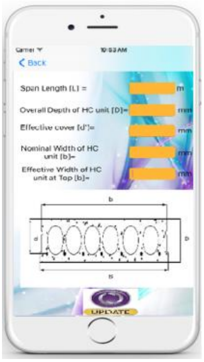
The GUI is achieved by writing step by step procedure of required design by writing flow chart for the development, the flow chart is described in previous session. The developed GUI screens of the application like in mobile are shown below.

Screen-1

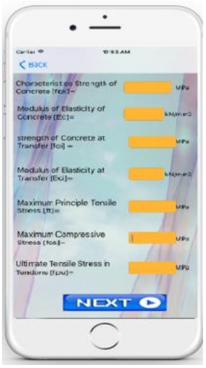
Screen-2



Screen 1-1

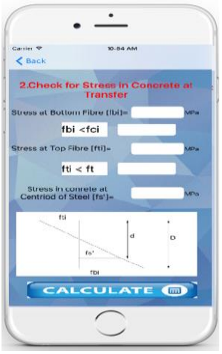


Screen 1-2



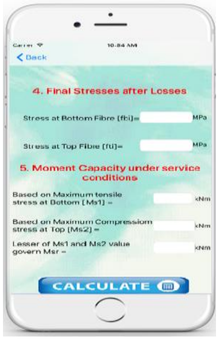
Screen 1-3

Screen 1-4



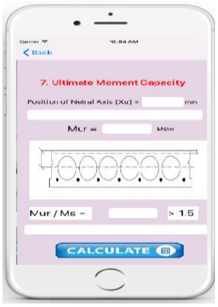
Screen 1-5

Screen 1-6

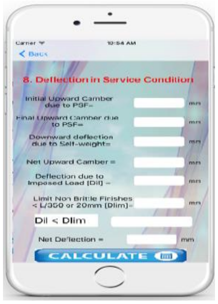


Screen 1-7

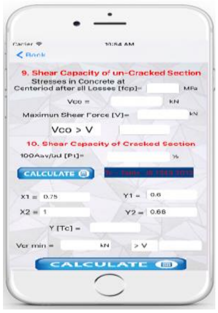
Screen 1-8



Screen 1-9



Screen 1-10

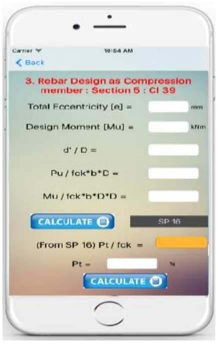


Screen 1-11

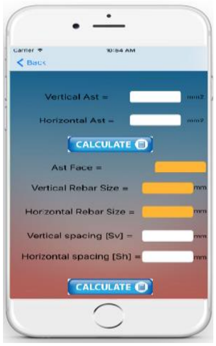
Screen 1-12

Screen 2-1

Screen 2-2



Screen 2-3



Screen 2-4

Fig 3.1 GUI of developed screens

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 08 | Aug -2017 www.irjet.net p-ISSN: 2395-0072

3.2 Building of Application in X-code

X-code is an integrated development tool used for building applications for iPhone and iPad. X-code contains of several tools, the most used are source code, editor and debugger and interface builder. Swift programming language is used in X-code for coding, making iterations and developing application. X-code comes bundled with a wonderful IOS simulator to test the application. In fact, IOS simulator is used for most development and then to find a device to test on when you are nearly done.

Procedure

1. The launch screen of the X-code which has the options of selecting 'creating a new project', 'playground' and 'existing project. Selecting on new project.
2. Choose a template for the new project as Single view application.
3. The figure 3.2 shows the basic layout of X-code which contains of story-board, assistant editor, debug area, assistant tools, inspector panel, navigation panel etc.

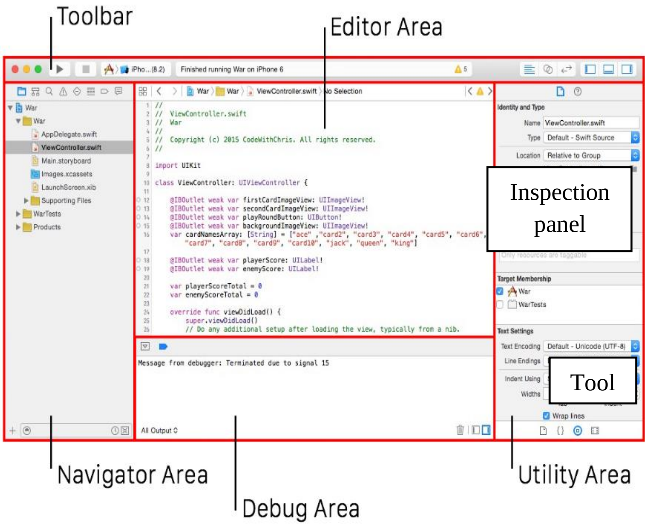


Fig 3.2 Layout of X-code

4. The screens of the application are shaped by drag and dropping the view controller tool from tools panel to the main story board likewise numerous screens can be created, and applying navigation controller benefits in navigating between one screen to another. Inspector panel lets to set the background color, screen size for the view controller. GUI for the application is done on view controller like placing buttons, labels, text fields, image view etc.
5. Coding is done in cocoa touch class using assistant editor. To create cocoa touch class File -> New -> File -> Cocoa touch class. Buttons and text fields which are placed on the view controller are connected to the assistant editor where the coding can be done to perform certain required actions.
6. After implementation of coding into the assistant editor, the application is tested by running it in the simulator. Simulator is a virtual phone which allows the developer to run the application so that he can find out bugs if any.

4 Use of Developed App for the Design of Precast Hollow core slabs and Wall panels

1. The axial forces which are obtained from the analysis using ETABS are taken into account for the design of wall panels and are inputted into the developed IOS application which provides the rebar distribution, spacing of rebar and pitch in both horizontal and vertical direction as per the procedure discussed.

2. The design and check for moments, deflection, shear and bearing capacity for Hollow core slab for the residential building is done in the developed IOS application and the results are discussed below.

4.1 Results of Wall panels using developed App

From fig 4.1 the wall panel 1WL3 at storey level-1 is designed with the help of application and the results of reinforcement and spacing in both horizontal and vertical direction are shown in fig 4.2.

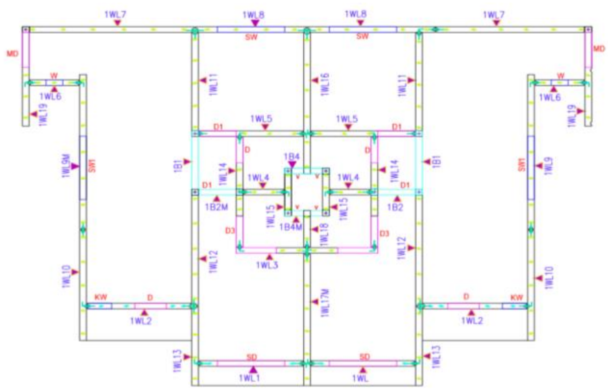


Fig 4.1 Wall panel layout

4.2.1 Design of Wall panel – 1WL3 at storey-1

Height of the wall (H) = 3 m

Thickness of wall (t) = 160 mm

Length between cross walls (l_c) = 3.3 m

Concrete Grade fck = 25 MPa

Steel Grade fy = 415 MPa

Effective length factor K = 0.75

Factored load (P_u) = 1250 kN

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 08 | Aug -2017 www.irjet.net p-ISSN: 2395-0072

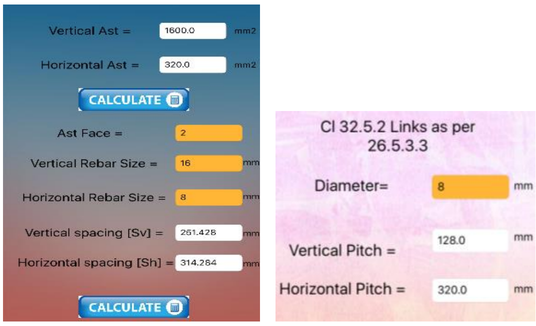


Fig.4.2 Results of Rebar design

By using the developed IOS application the reinforcement distribution and pitch for wall panel-1WL3 is shown in fig 4.2. The rest of the wall panels are designed and detailing of each wall at storey level-1 are tabulated in table 4.1

Table.4.1 Results of Rebar design at storey level-1

Wall panel name	Length and height (m)	Load (kN)	Ast Face	Vertical Ast_v (mm^2)	Vertical rebar spacing (mm^2)	Horizontal Ast_h (mm^2)	Horizontal rebar spacing (mm^2)
1WL1	2.5 x 3	560	1	192	#8@250	320	#8@150
1WL2	2.4 x 3	650	1	192	#8@250	320	#8@150
1WL3	3.3 x 3	1247	2	1600	#16@250	320	#8@300
1WL4	1 x 3	440	1	192	#8@250	320	#8@150
1WL5	2.5 x 3	750	1	192	#8@250	320	#8@150
1WL6	1.3 x 3	500	1	192	#8@250	320	#8@150
1WL7	4 x 3	760	1	192	#8@250	320	#8@150
1WL8	2.8 x 3	580	2	1600	#16@250	320	#8@300
1WL9	4.4 x 3	1200	2	1600	#16@250	320	#8@300
1WL10	3.1 x 3	1450	2	2400	#16@160	320	#8@300
1WL11	2.9 x 3	1266	2	1600	#16@250	320	#8@300
1WL12	3 x 3	1300	2	1600	#16@250	320	#8@300
1WL13	2.2 x 3	1125	2	1600	#16@250	320	#8@300
1WL14	3.1 x 3	800	1	192	#8@250	320	#8@150
1WL15	1 x 3	470	1	192	#8@250	320	#8@150
1WL16	4 x 3	1609	2	3200	#20@180	320	#8@300
1WL17	3.7 x 3	1786	2	3200	#20@180	320	#8@300
1WL19	2.8 x 3	650	1	192	#8@250	320	#8@150

4.2 Results of Hollow core slabs using developed App

The fig 4.3 shows the slab layout of the residential building and the table 4.2 shows the dimensions of each slab. The slab thickness is taken as 150mm for all the panels and designed using the application. The maximum moments due to service condition, ultimate moment carrying capacity and deflections of slabs are noted. The slab design is done at storey level-1 and the same layout is taken in all the storeys.

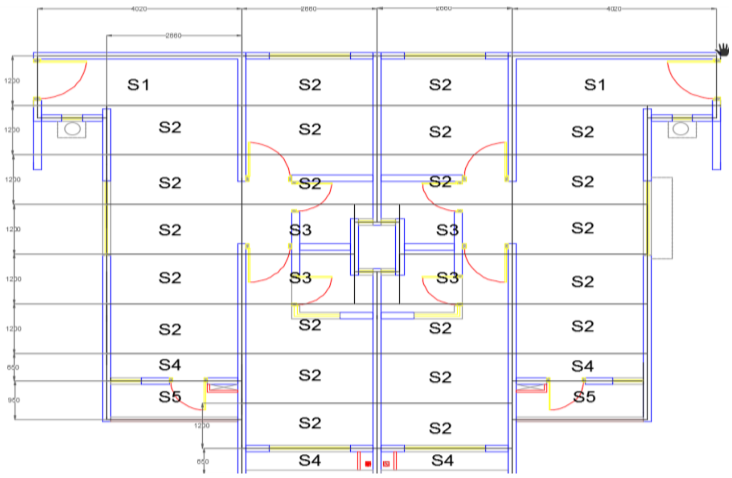


Fig.4.3 Slab Layout

4.2.1 Design of Hollow core slab – S2 at storey level-1

Imposed load (DL+LL) = 5 kN/m^2

Overall depth (D) = 150 mm

Effective cover (d') = 35 mm

Nominal width of HC unit (B) = 1200 mm

Thickness of top flange (t_f) = 17 mm

Characteristics strength of concrete (f_{ck}) = 50 MPa

Modulus of elasticity of concrete (E_c) = 30 kN/mm^2

Ultimate tensile Strength in tendons (f_{pu}) = 1600 MPa

Modulus of elasticity of prestressing steel (E_{ps}) = 200 kN/mm^2

Area of prestressing steel (A_{ps}) = 52 mm^2 per strand

Number of Strands (n) = 9

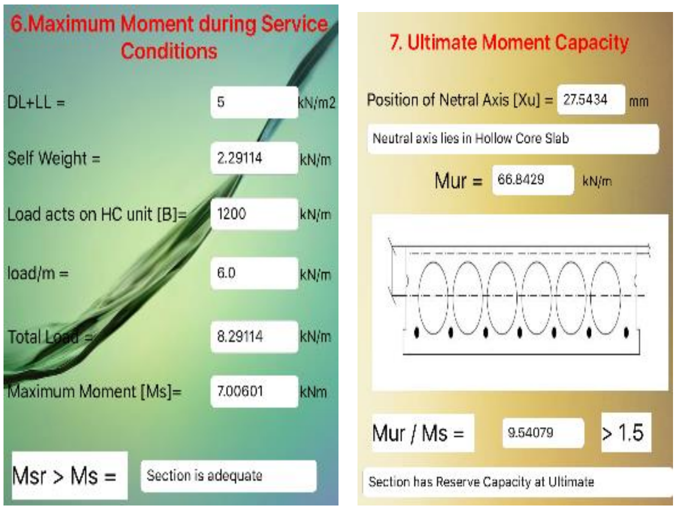


Fig.4.3 Results of under service condition and ultimate moment carrying capacity

The Bending moment results of the Hollow core slab S2 is calculated by using developed IOS application and its and moment under service condition Ms = 7kNm The Ultimate moment capacity Mur = 66.82kNm in fig 4.3 the factor of safety for the ratio of ultimate moment carrying capacity by moments under service condition is 9 which is greater than 1.5, hence the section has reserve capacity.

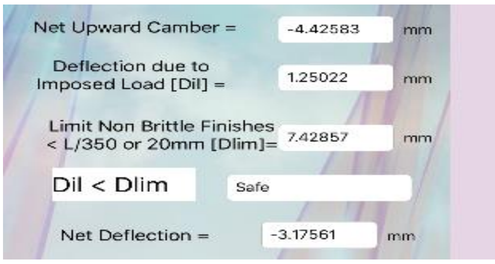


Fig.4.3 Results of deflection

The results of total deflection of Hollow core slab S2 is 1.2mm which is less than span by 350 or 20mm whichever is less, by considering the effects of temperature creep and shrinkage occurring after erection of partition and the application of finishes. Similarly the other slabs where designed, checked and are tabulated for moments and deflection from the developed IOS application are shown in table 4.2

Table.4.2 Detailing of Hollow core slab at Storey-1

Slab No	Breadth Lx, (m)	Span Ly (m)	Moments under service condition M_S (kNm)	Moment Resistance M_{SR} (kNm)	Ultimate Moment carrying Capacity M_{UR}, (kNm)	Number Of Strands (N)	Deflection, (mm)
S_1	4.1	1.2	16.58	39.12	66.84	9	-1.927
S_2	2.6	1.2	7	39.12	66.84	9	-3.7
S_3	2.2	1.2	5.016	39.12	66.84	9	-2.62
S_4	2.6	0.65	3.86	21.44	36.92	5	-3.22
S_5	2.6	0.95	5.4	33.23	58.49	8	-3.75

3.2 CONCLUSIONS

1. To carry out the design calculations for precast hollow core slabs and precast wall panel, an IOS application has been developed in swift code

2. With the use of IOS application the time taken for design calculations for precast Hollow core slabs and precast wall panels are reduced.

3. With the use of IOS application the complexity involved in design of precast hollow core slab and precast wall panel is reduced, since it is not required to know all the procedure and equation for the design process.

4. The precast hollow core slabs and wall panels of all floors of the structure considered are designed and tabulated and design results are represented in the table.

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