EXAMPLE
Permanent Accommodation Building
‘Blast’ Analysis

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1. Introduction

The project consists of six nearly identical buildings of maximum plan dimensions of 101.92 x 22.16 m. Each building has a ground floor plus two storeys with a 1m parapet on the rooftop.
The storey height is 3.2 m.

The buildings are situated on a remote Island in the Emirate of Abu Dhabi. This situation coupled with the usage of these buildings as living quarters for Oil & Gas exploration sites consisting of repetitive units make the modular precast construction system an obvious choice.

It is suggested that the buildings shall be raised approximately 1m above the natural ground by short modules that rest on strip foundation. The short modules will, intern, support the ground, first and second floors as shown in Fig. (1).

The cross-section of the building in the short direction as reflected in Fig. (1) Shows two side modules connected by a corridor slab that joins the assembly together by steel plates properly anchored to concrete elements.

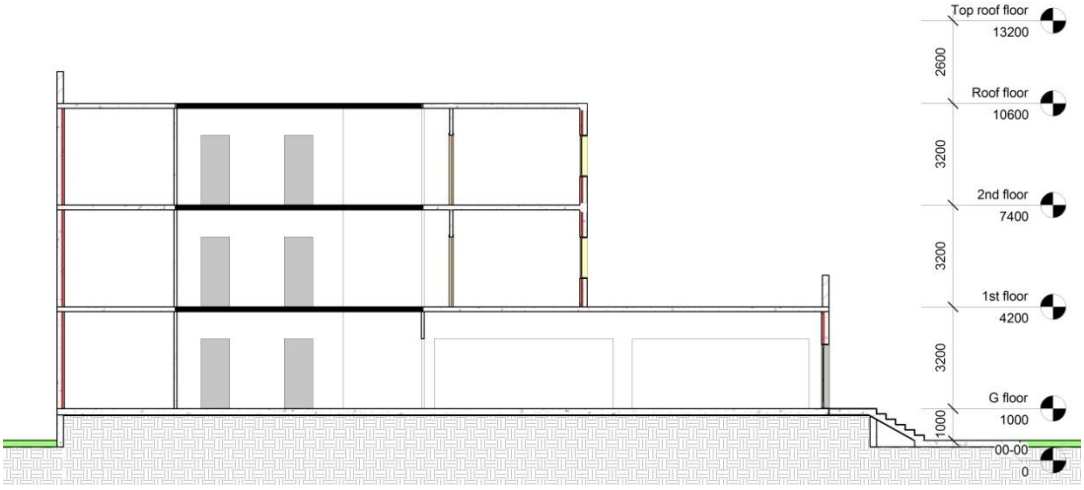

Fig. (1)

2. Design Assumptions & Criteria

The modules shall be made of precast reinforced concrete having the following material properties:

a- Concrete C – 40 for all precast and cast in-situ construction with provisions for durability for the sub as well as the super structure. Reinforcing steel yield strength = 460 mpa.

b- Design loads are as follows :

i- Dead load
ii- Super imposed dead load = 2.5 kpa
iii- Live load living quarters = 2 kpa, corridors = 5kpa
iv- Wind load basic wind speed = 45 m/s
v- Earthquake zone = 2 A
vi- Explosion impact load in the three orthogonal directions = 25 kpa
vii- Design Fire Duration = 2 hrs
viii- Allowable soil pressure = 1.5 kg / cm2 = 150 kpa

c- Design provisions of the ACI 318 M – 08 and any other local or international code where necessary shall be employed.

3. Elements of Design

3.1 Design of Foundation:

a- Overturning:

The critical condition for overturning in the minor (weak) axis was investigated under the incidence of an impact horizontal pressure wave of a static value of 25 kpa with only the dead load present:

The overturning moment / module depth = 6473 KN-m

The dead load restoring moment/ module depth = 12265.4 KN-m

Factor of Safety = 12265.4 / 6473 = 1.89 O.K.

b- Design of Strip Foundation:

Using the load assumptions noted in 2-b above:

Total service foundation load = 165.6 KN/m

Minimum foundation thickness as per ACI code section 15.7

Thickness t (min.) = 23cm

Assume strip width B = 1.2 m

Applied service foundation pressure =138 kpa< 150 kpa

Wu = 203.2 KN/m, Mu = 36.6 KN-m / m

$Rm = Mu / \Phi b d^2 = 1.33$

Fc` = 32 Mpa , fy = 460 Mpa

$\boldsymbol{\rho} = 0.85 Fc` / fy (1- \sqrt{(1 – 2Rm / 0.85 Fc`)})$

$\boldsymbol{\rho} = 0.0030 = \boldsymbol{\rho}$ min = 0.0033

As = 0.0033 x 155 x 1000 = 512 mm^2 / m

T 12 @ 200 gives 565 mm2 / m O.K.

$\boldsymbol{\rho}$ min , longitudinal = 0.002

As = 0.002 x 150 x 1000 = 300 mm^2 / m

6 T 10 give 6 x 78.5 = 471 O.K.

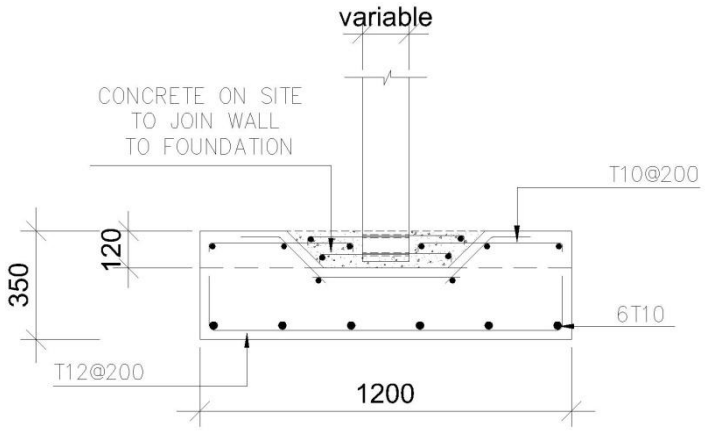

Fig. (2)

3.2 Welded steel plate connecters against impact horizontal shear:

Total impact horizontal shear along 5.06 m long wall @ GF level = 1341 KN

Total impact horizontal shear along 3.54 m long wall @ GF level = 938 KN

Assume fy for weld = 420 mpa, allowable shear stress = 0.4 fy = 168 mpa

Assume fillet weld size 6mm.

Allowable fillet weld Fw = 0.707 x 6 x 168 = 713 N/mm

Length of weld required (both sides):

Lwl = 1341 x 1000 / 713 x 2 = 940 mm

Provide double 6mm fillet weld @ three locations of 40 cm @ ends and center of wall.
Table 1 shows the lengths of welds required for various locations.

Table 1-
Lengths of welds double faced in cms.

Level	Long direction	Short direction
GF	40	30
1st Floor	30	20
2nd Floor	20	15

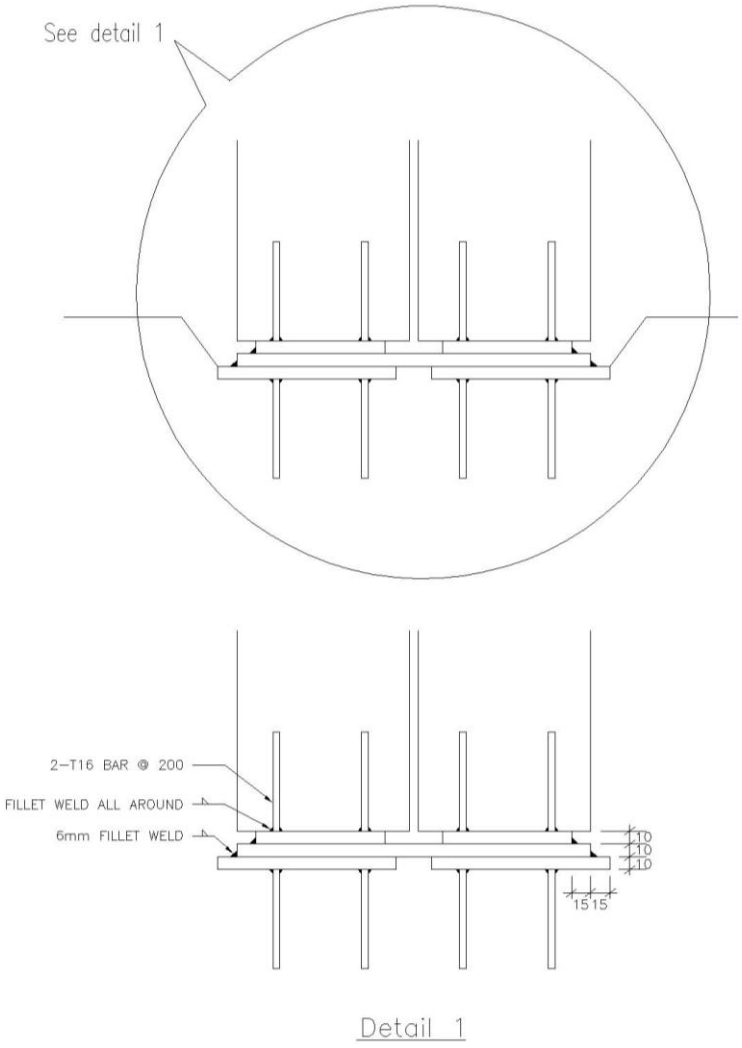

Fig. (3)The welding details and steel plate anchors

4. SAFE Model

a- Assumptions

Computer SAFE models were created for the roof units, the exterior wall of horizontal dimensions of 3.54 and 5.06m. Each slab model rested on wall and slab supports with their respective thicknesses to provide a realistic end continuity conditions. Horizontal roof slabs only were subjected to their dead loads and an equivalent impact load of 25KN/m2. Vertical exterior wall units were subjected to impact load only of 25KN/m2.

b- Results

The computer results are provided in software and samples of deformed shapes and principal moments are shown in Figs. (4, 5, 6,7& 8).

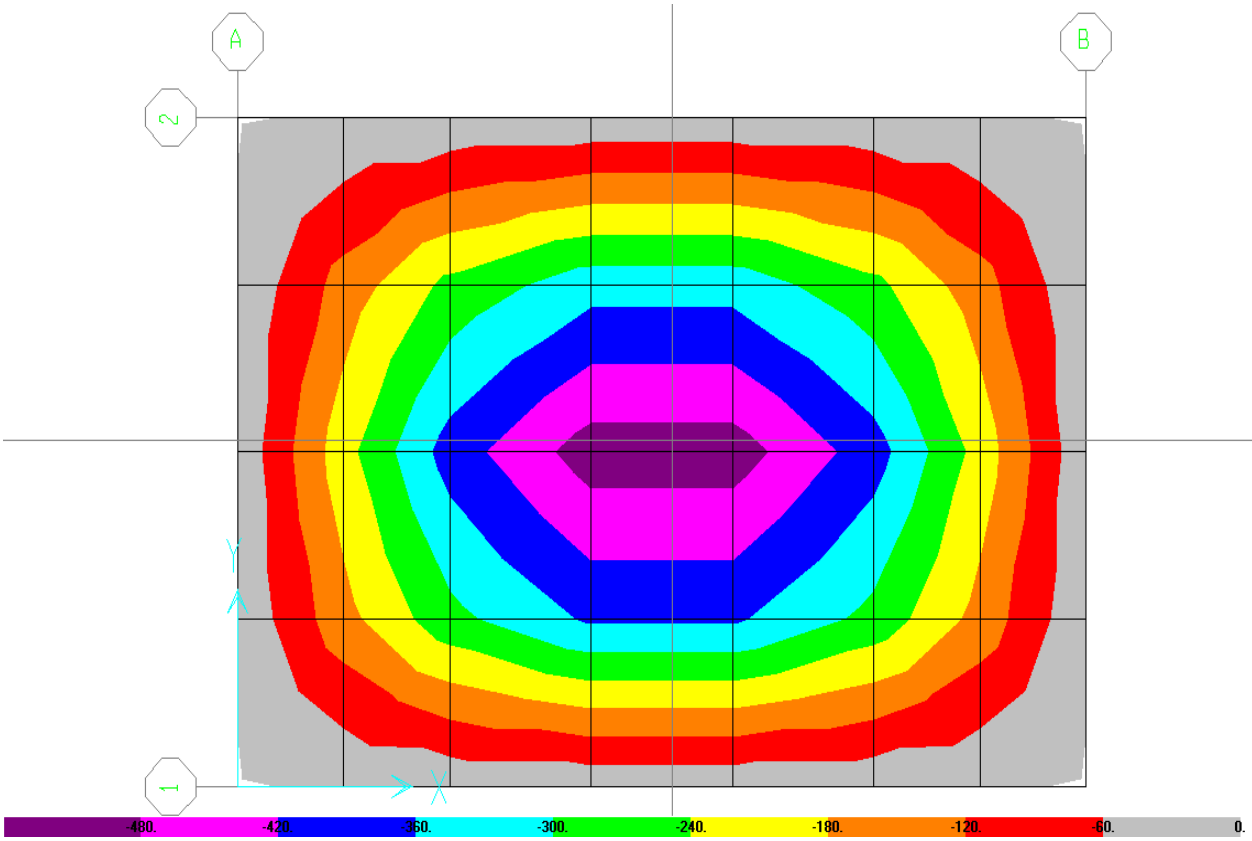

Fig.(4) – Deformed Shape of roof slab (DL+LL)

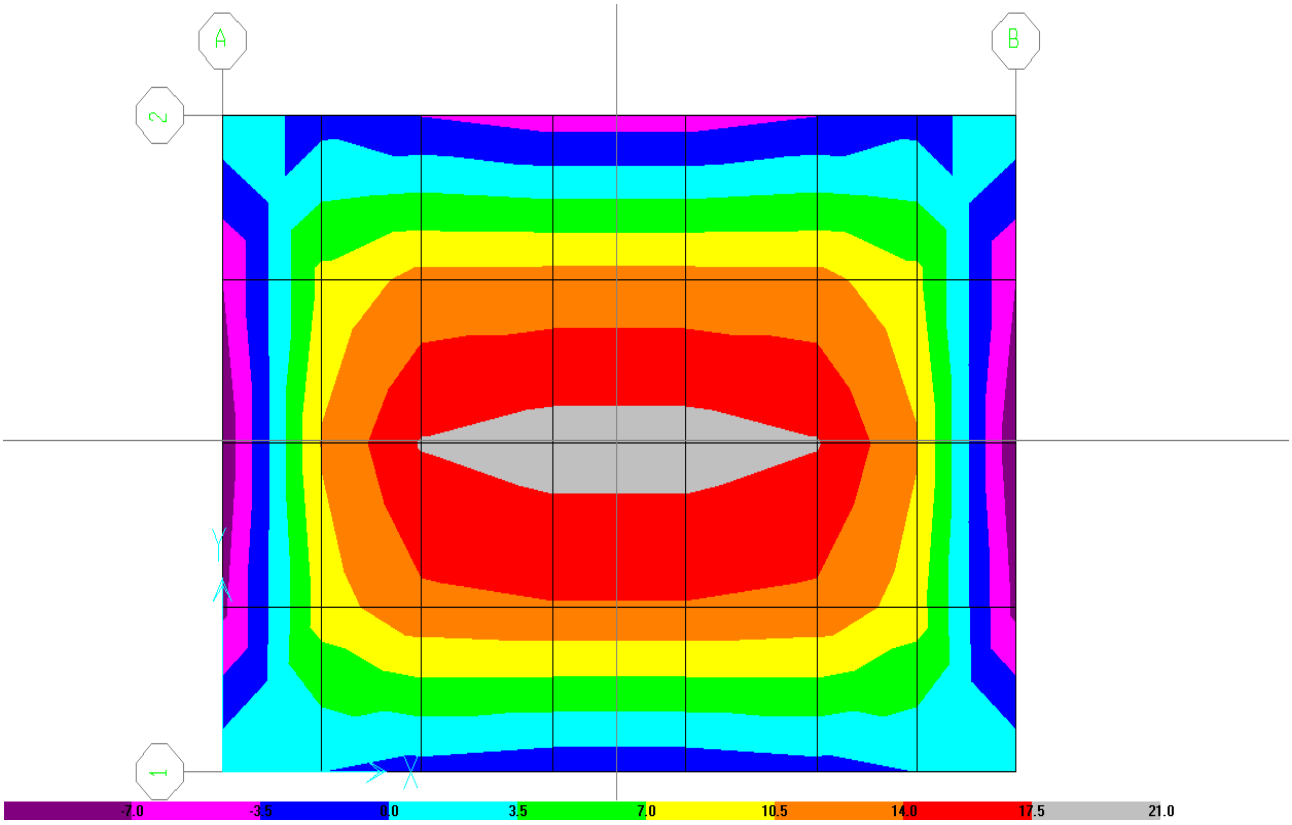

Fig.(5) – Ultimate Moment Mxx In Roof Slab under (DL+SDL+Impact)

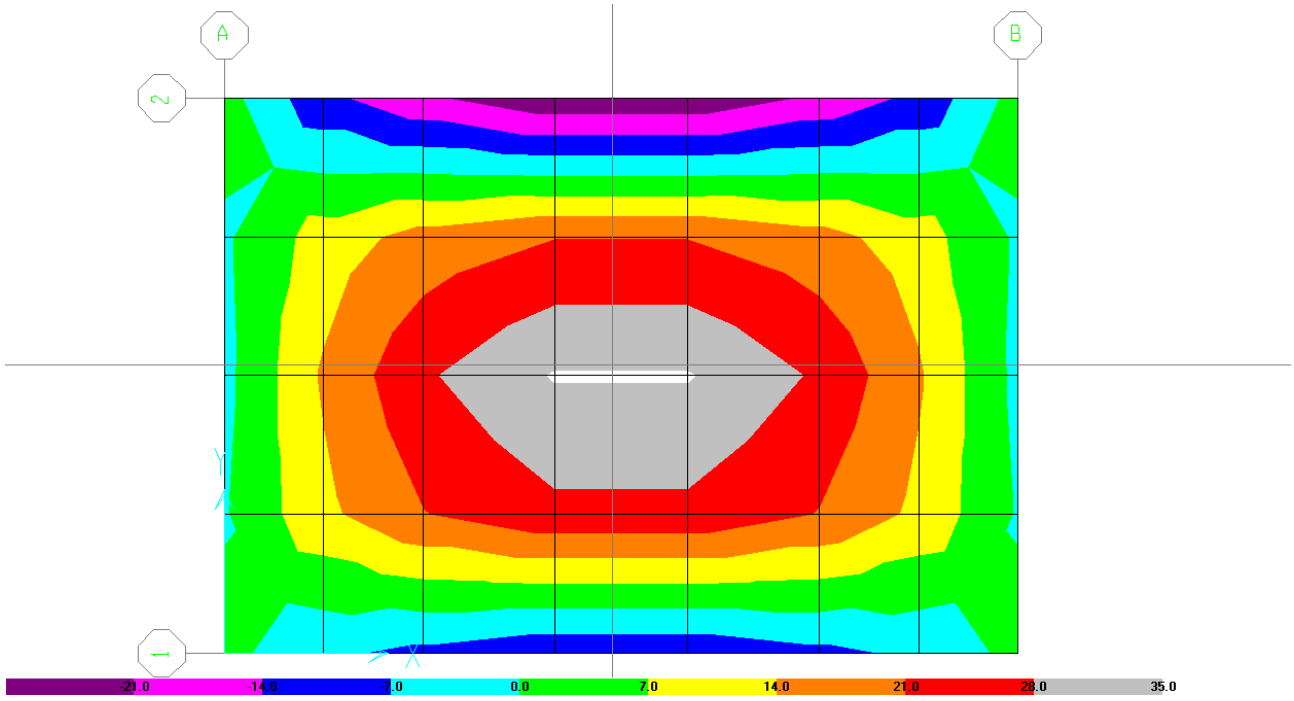

Fig.(6) – Ultimate Moment Myy In Roof Slab under (DL+SDL+Impact)

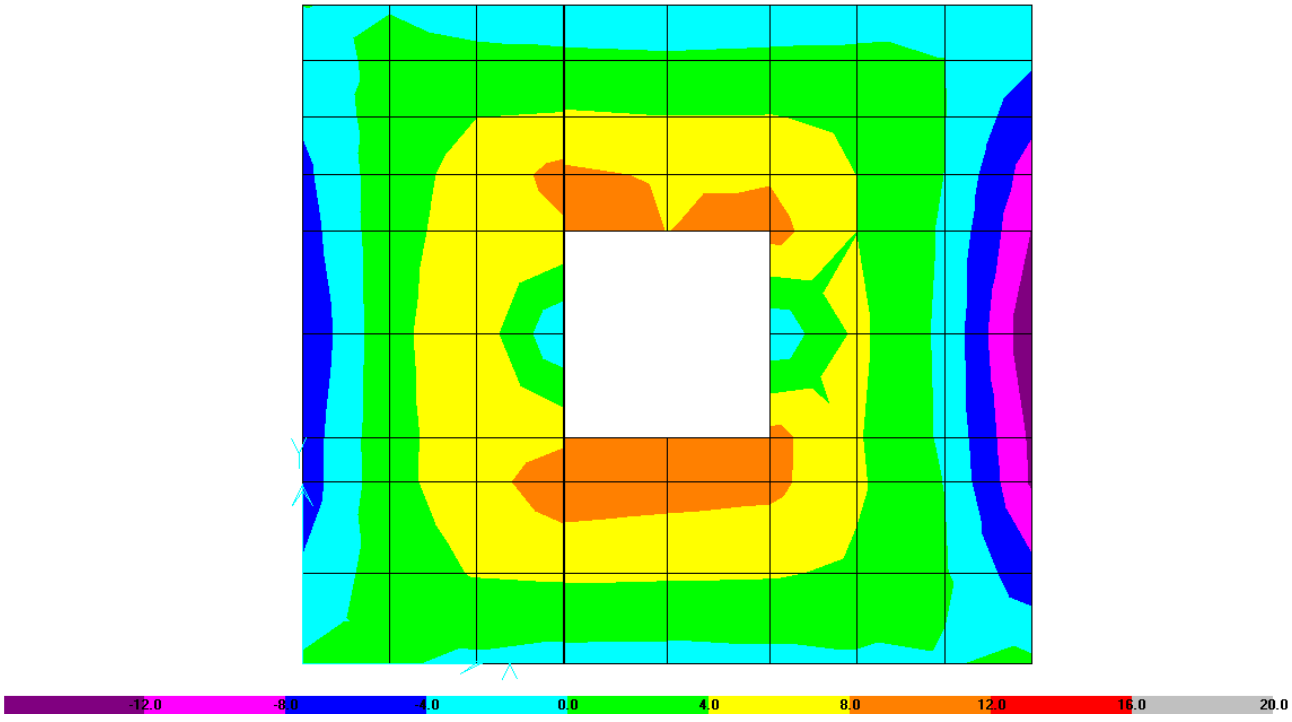

Fig.(7) – Ultimate Moment Mxx in Exterior Wall with opening under Impact

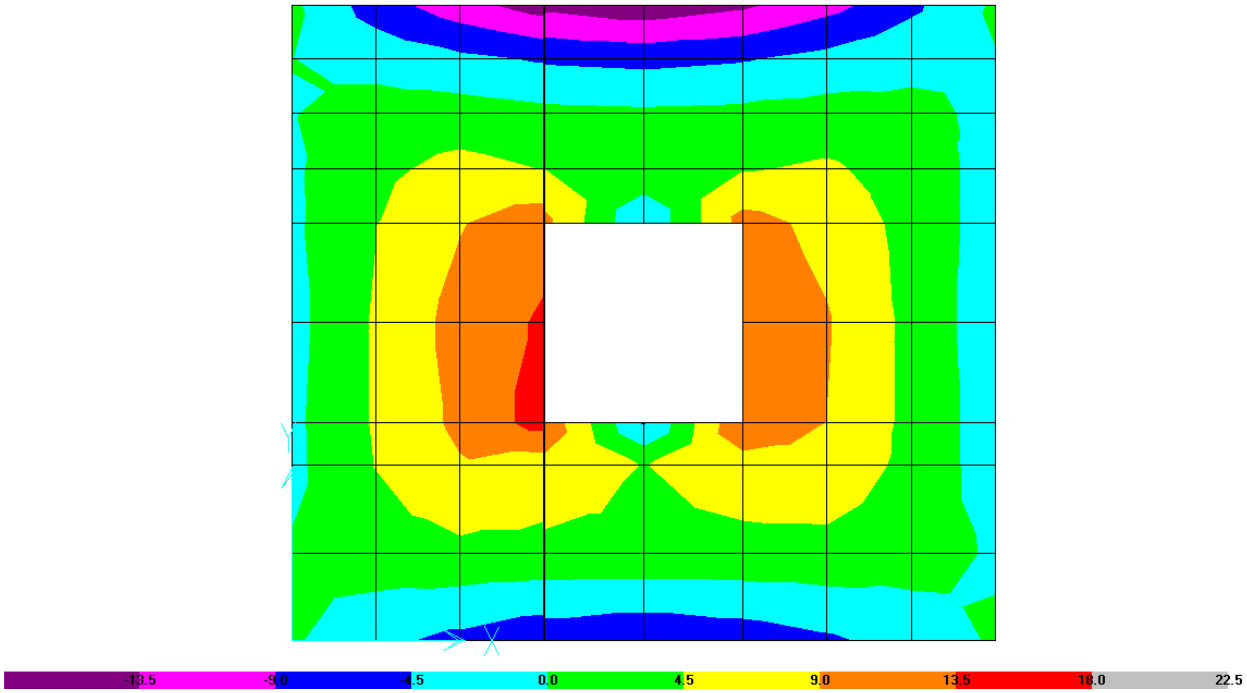

Fig.(8) – Ultimate Moment Myy in Exterior Wall with opening under Impact

5. ETABS MODEL

a- Assumptions :

A 3D- ETABS Model was created for the whole building as shown in Fig.(9). The loads subjected were Dead Loads (DL), Superimposed Dead Load (SDL), Live Loads (LL), Wind Loads (W), Earthquake Loads (EQ) and Impact Loads (IM). Load combination were chosen as per ACI 318M-08 and UBC-97 codes. Analysis and Design runs were conducted. Serviceability and strength requirements of the codes were met satisfactorily.

b- Results

The computer results are provided in software. Samples of deformed shapes and internal forces and moments are shown in Figs.(9 & 10) and Table (2).

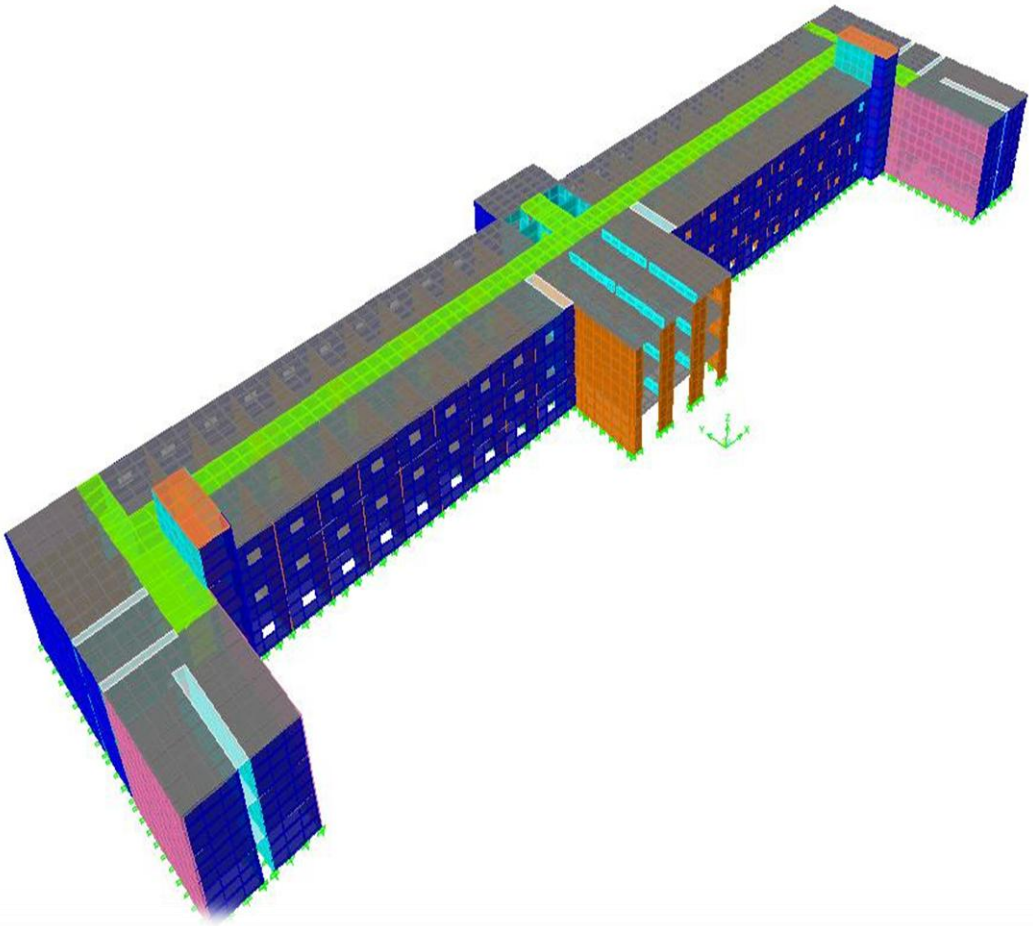

Fig.(9) – 3D Model for the whole building

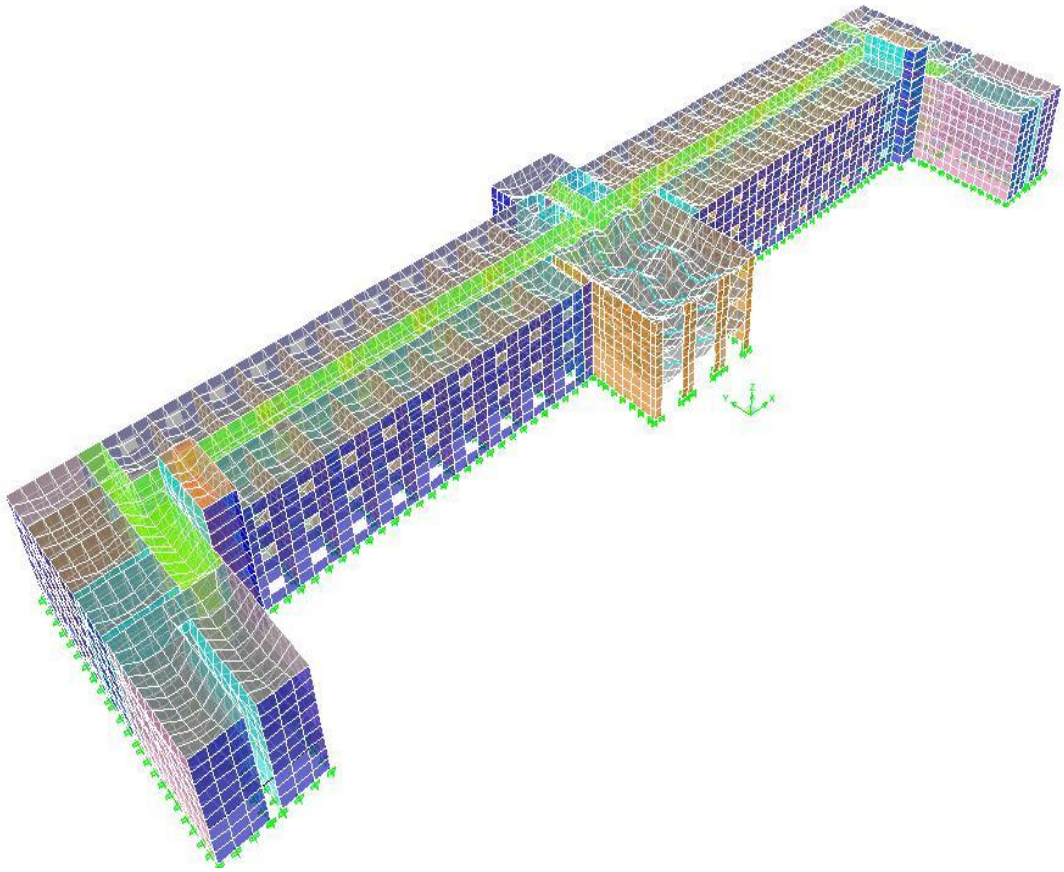

Fig.(10) – 3D Deformed shape under (Impact+DL+SDL+LL)

Story	Pier	Load	Loc	P	V2	V3	T	M2	M3
STORY1	P37	UDLIM2Y	Top	-107.43	-19.13	-4.87	0.041	4.302	26.369
STORY1	P37	UDLIM2Y	Bottom	-101.95	4.02	0.62	0.197	0.114	-16.294
STORY1	4	UDLIM2Y	Top	-107.39	19.15	-4.87	-0.041	4.302	-26.353
STORY1	4	UDLIM2Y	Bottom	-101.85	-3.97	0.62	-0.197	0.114	16.349
STORY1	37	UDLIM2Y	Top	-869.57	-6.04	1153.91	115.129	-386.844	182.887
STORY1	37	UDLIM2Y	Bottom	-389.9	-13.92	-1132.74	-82.63	-355.881	387.565
STORY1	39	UDLIM2Y	Top	-869.37	8.08	1153.91	-115.131	-386.844	-184.548
STORY1	39	UDLIM2Y	Bottom	-389.67	15.9	-1132.74	82.629	-355.882	-388.157
STORY1	40	UDLIM2Y	Top	-229.61	0.17	328.55	-0.001	-145.953	0.269
STORY1	40	UDLIM2Y	Bottom	-204.47	0.17	-313.09	0	-123.283	0.554
STORY1	41	UDLIM2Y	Top	-138.44	-135.24	1.94	1.065	1.389	31.495
STORY1	41	UDLIM2Y	Bottom	-139.38	-196.73	-7.25	-1.256	-4.777	-186.662
STORY1	42	UDLIM2Y	Top	-138.3	-135.16	-1.94	-1.065	-1.389	31.374
STORY1	42	UDLIM2Y	Bottom	-139.2	-196.69	7.25	1.256	4.776	-186.762

Table 2 – Sample results for exterior walls under (DL+SDL+LL+Impact)

6. Conclusion

The structure for the permanent accommodation building as provided by the Livin Modular has been analyzed and designed according to the ACI318M-08 & UBC-97 Codes and was found to be satisfactory.