Dynamic Analysis of G+15 Multi-storied RCCCommercial Buildings with Different Plan Configuration in Seismic Zone V using ETABS 2018

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Abstract:

Buildings in present scenario are having asymmetry in both in plan and elevation, which may subject to hazardous seismic ground vibrations causing collapse of building structure. Therefore, it is required to find out the behavior of the structures to survive against seismic forces in order to prevent the loss of life. This paper looks at the study of seismic response of the buildings with six different plan configurations. Response Spectrum Analysis has been carried out for six G+15 multi-storied RCC commercial buildings with different plan configuration (Rectangular, L, I, O, T and U) in seismic zone V using ETABS 2018 software. The analysis is carried out as per the latest Indian seismic code 1893(Part-1):2016"Criteria for Earthquake Resistant Design of Structures". The responses obtained for each structure are compared. It is observed from the results that, all the buildings exceed the permissible limit for drift by about 36% and permissible limit for displacement by about 96%. Furthermore, the irregular shapes buildings (L, I, T and U) shows poor performance than regular buildings (Rectangular and O); U-Shape building is the worst among all.

Keywords— ETABS, Response Spectrum, Storey Displacement, Storey Drift, Storey Shear, CM Displacement, Storey Overturning Moment, CM and CR.

I. INTRODUCTION

Seismic ground motions are caused by tectonic movements in the Earth's crust. The main reason for earthquake is when tectonic plates collides and rides one over the other, initiating hazardous earthquakes vibrations. The vibrations set up in the earth's crust, causing earthquakes which spread outward in all directions from the source of origin.

One of the latest earthquakes that occurred recently was in Nepal. On 25 April 2015, earthquake of magnitude around 7.8 destroyed housing in the Kathmandu, damaged the Word Heritage sites, and triggered deadly avalanches. Thus it is necessary to analyze and design the structures for hazardous seismic forces in order to prevent the loss of life and capital.

1.1 TYPES OF RCC FRAMES

Here the study is carried out for the behavior of G+15 multistoried RC commercial buildings with different plan configuration in seismic zone V. The modeling and analysis is done in ETABS 2018 and as per IS1893 (Part-1):2016 "Criteria for Earthquake Resistant Design of Structures". Six different plan configuration which are considered for the seismic analysis of the same structure, are mentioned below-

1. L-shape building
2. Rectangular shape building
3. U-shape building
4. O- shape building
5. I- shape building
6. T-shape building

The building is modeled in plan of 24m x 28m.Center to center spacing of 4m is considered in between columns. A height of 3m is assumed in between floor to floor. Plan and 3D view of the buildings for all the proposed cases are shown in the Fig. 1 to Fig. 6.

Following are the material properties consideredfor the analysis of the structures-

1. Steel grade: HYSD500
2. Concrete grade: 30Mpa for columns and 25Mpa for beams

3. Number of stories: 16
4. Columns size from Foundation to 4^{th}storey: 700mm x 700mm
5. Columns sizefrom 5^{th} – 9^{th}storey: 600mm x 600mm
6. Columns sizeabove 10^{th}storey: 500mm x 500mm
7. Main beams size: 400mm x 450mm
8. Plinth beams size: 230mm x 450mm
9. Parapet wall height: 1m
10. Main wall and parapet wall thickness: 230mm
11. Slab thickness: 150mm

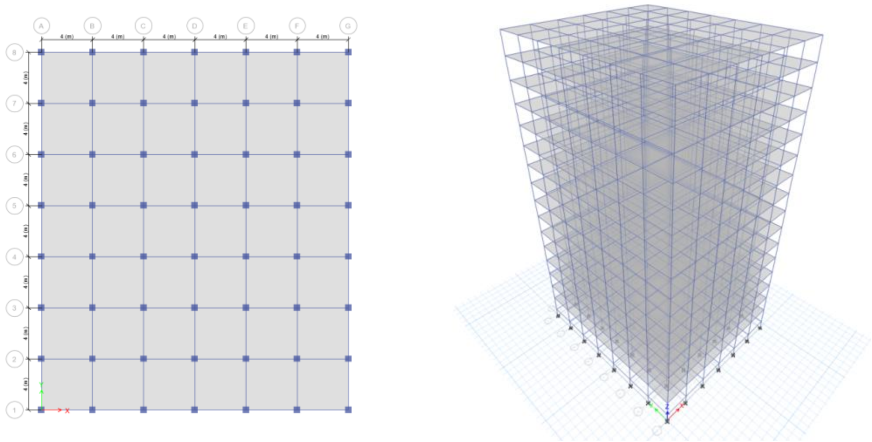

Fig.1: Plan and 3D view of Rectangular Shape RCC Building

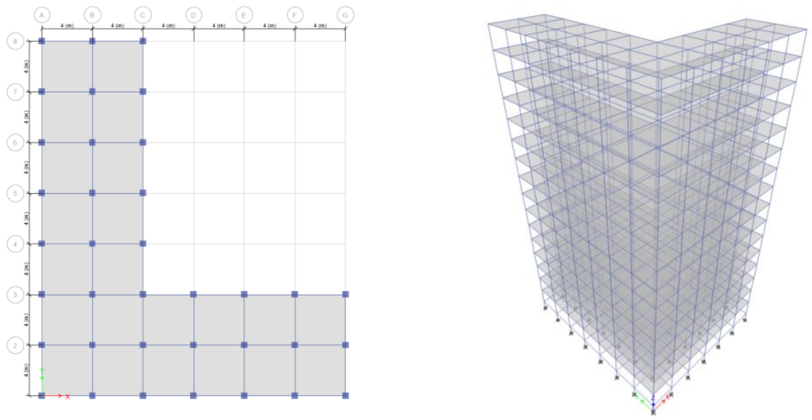

Fig.2: Plan and 3D view of L Shape RCC Building

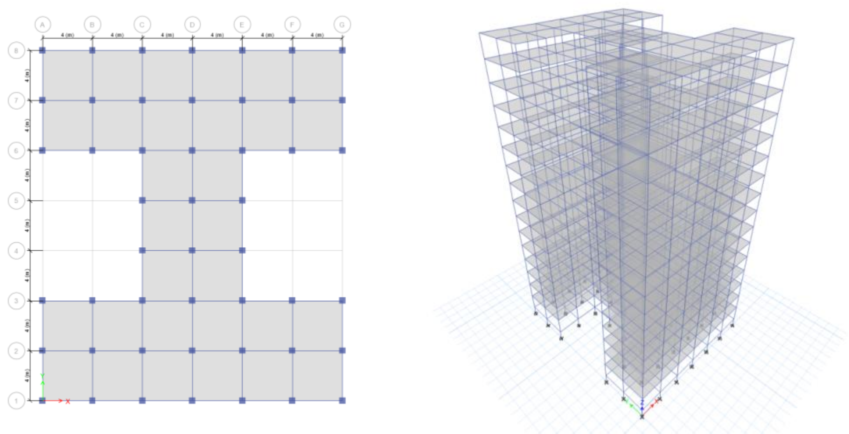

Fig.3: Plan and 3D view of I Shape RCC Building

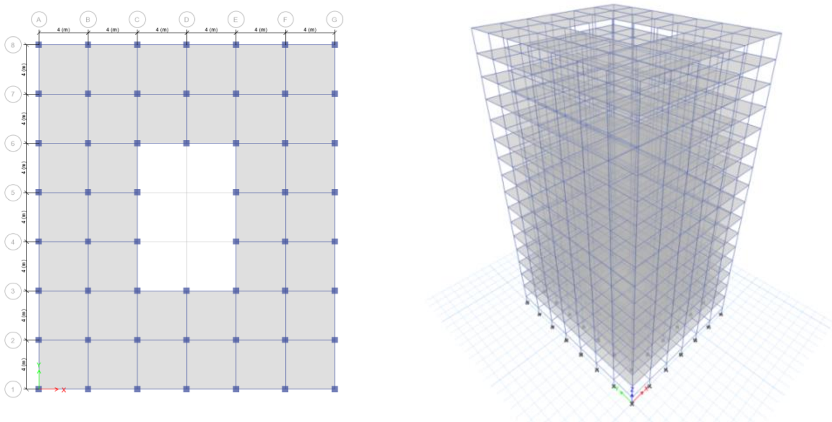

Fig.4: Plan and 3D view of O Shape RCC Building

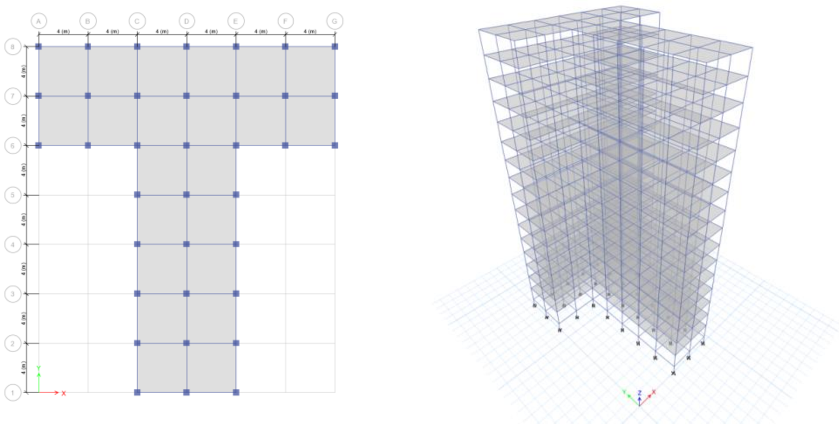

Fig. 5: Plan and 3D view of T Shape RCC Building

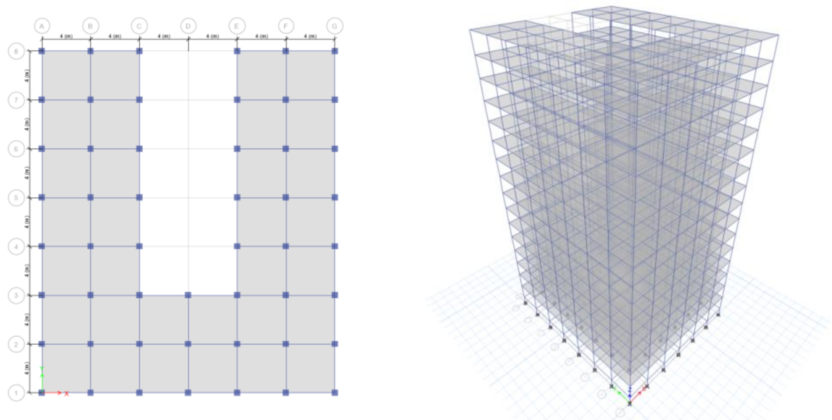

Fig.6: Plan and 3D view of U Shape RCC Building

1.2 PROBLEM FORMULATION

For the analysis of all the six considered structures, following are the loads which are assigned to all the structure-

1. Self-weight of the structure is automatically assigned by the ETABS software.
2. Dead Load (DL): DL of the structure consistthe followings, according to (IS 875 (Part1) - 1987).
    i. Wall load: Wall load is calculated by multiplying the unit weight of a brick with thickness andthe height of the wall = 19 KN/m^3 X 0.230m X (3 - 0.45) m = 12.5 KN/m.
    ii. Parapet Wall load: It is calculated by multiplying the unit weight of a brick with thickness andthe height of the parapet wall = 19 KN/m^3 X 0.23m X 1m= 4.9 KN/m.
    iii. Floor load: Floor load is calculated by multiplying the unit weight of concrete with the thickness of floor finish= 25 KN/m^3 X 0.050m = 1.5 KN/m^2.

3. Live Load (LL): LL consists of Floor load which is taken as 3.5KN/m2 for Business Computing machine rooms (with fixed computers or similar equipment) and Roof load as 1.5 KN/m2, according to (IS 875(Part 2) - 1987).
4. Earthquake Load: Following are the seismic parameters from IS 1893(Part-1): 2016 are taken as follows-
    i. Seismic zone: V (Zone Factor = 0.36)
    ii. Soil type: II (Medium soil)
    iii. Importance factor (I): 1.2 (Commercial building with occupancy more than 200 persons)
    iv. Response reduction factor (R): 5 for SMRF
    v. Damping: 5%.
    vi. Moment of inertia is taken as 70% of I_{gross} of columns and 35% of I_{gross} of beams

2. RESULTS AND DISCUSSIONS

For determining most stable and vulnerable structure among all models that we have analyzed, values and graphs are represented for different shapes of the building considered.

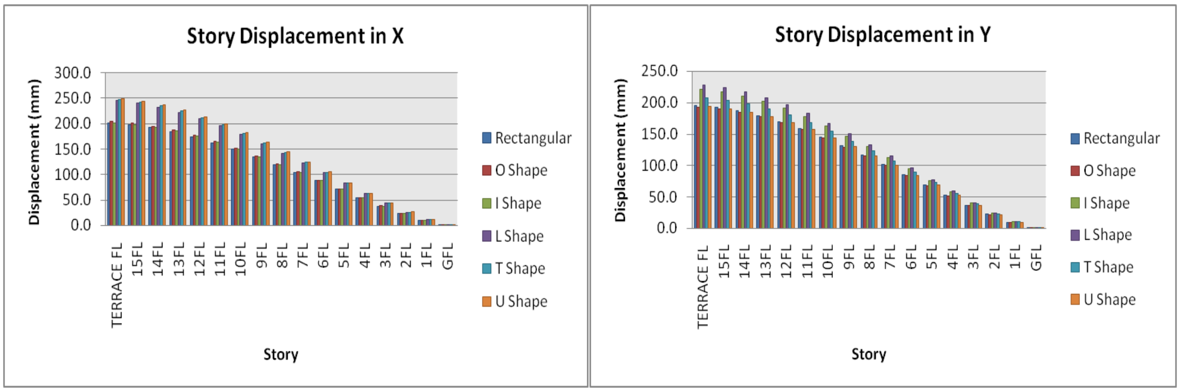

Fig. 7: Story Displacement Graph in X &Y-Dir for all Shapes of RCC Buildings

For story displacement in X- direction; Rectangular, O and I shape showing similar and better results as compared to other shapes of buildings and L, T and U shape building showing similar and maximum story displacement results as compared to other building.

For story displacement in Y- direction; L shape building showing maximum story displacement as compared to other shapes of buildings.

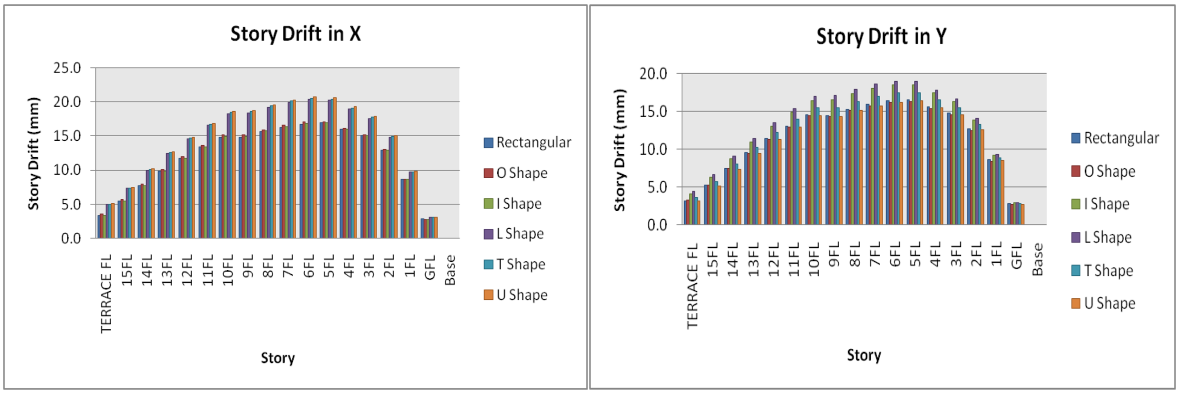

Fig. 8: Story Drift Graph in X &Y-Dir for all Shapes of RCC Buildings

It is observed that the storey drift increases up to 5th/ 6thstorey reaching to maximum value and then it started falling again. Drift for U shape building is maximum compared to other shapes of buildings in X direction and drift for L shape building is more compare to other shape of buildings in Y direction.

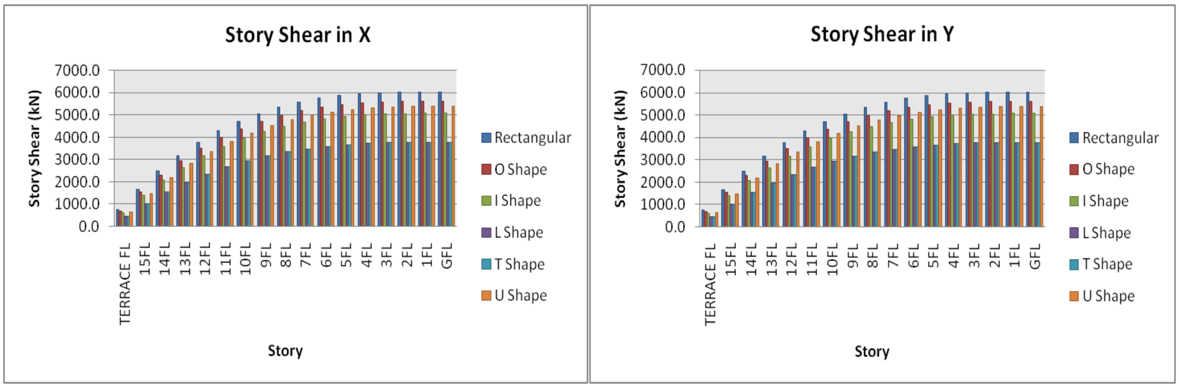

Fig. 9: Story Shear Graph in X &Y-Dir for all Shapes of RCC Buildings

The storey shear is observed to be decreasing with the height of building. L and T shape building has similar results and less storey shear compare to other shapes of buildings and Rectangular shape building has maximum base shear in both X and Y direction.

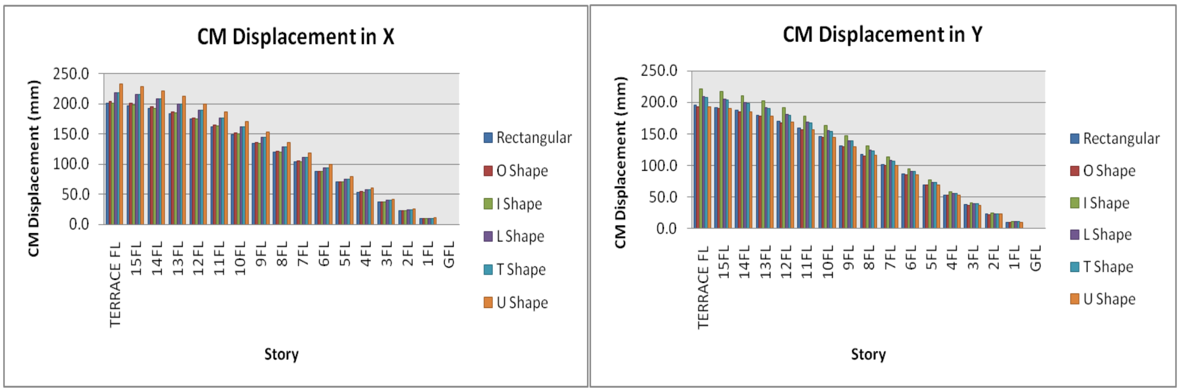

Fig. 10: CM Displacement Graph in X &Y-Dir for all Shapes of RCC Buildings

It is observed that the Center of Mass (CM) displacement increase with the increase in height of storey. CM displacement for U shape building is more compare to other shapes of buildings in X direction and CM displacement for I shape building is more as compare to other shapes of buildings in Y direction.

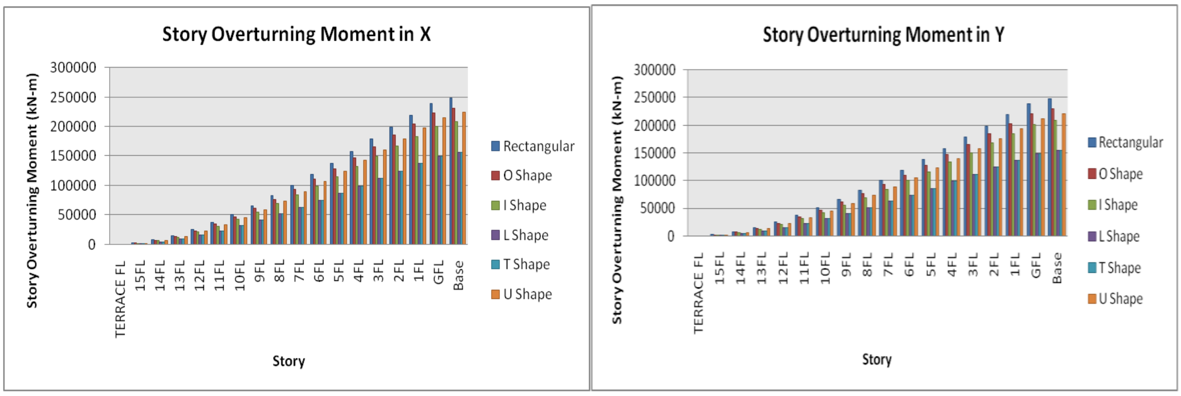

Fig. 12: Story Overturning Moment Graph in X & Y-Dir for all Shapes of RCC Buildings

The overturning moment varies oppositely with height of the storey. In case of Rectangular shape building, a moment produced is higher than other shapes of the building in both X and Y direction. Storey overturning moment for L and T shape building showing similar results and their overturning moments are less compared to other buildings in both X and Y direction.

Table 1: Centers Of Mass (m)					
Rectangular	O Shape	I Shape	L Shape	T Shape	U Shape
(12,14)	(12,14)	(12,14)	(8.6,10.6)	(12,17.4)	(12,13.2)

Table 2: Centers Of Rigidity (m)					
Rectangular	O Shape	I Shape	L Shape	T Shape	U Shape
(12,14)	(12,14)	(12,14)	(7.7,9.5)	(12,18.4)	(12, 12.2)

Table 3: Eccentricity (mm) in X					
Rectangular	O Shape	I Shape	L Shape	T Shape	U Shape
0	0	0	847.7	0	0

Table 4: Eccentricity (mm) in Y					
Rectangular	O Shape	I Shape	L Shape	T Shape	U Shape
0	0	0	1027.1	995.3	962.6

It is observed that only L shape building is eccentric in X direction and L, T and U shape buildings are eccentric in Y direction. Among all the buildings, L shape building has maximum eccentricity in both X and Y direction as the distance between the CM and CR is more as compared to other building which results in torsionally unbalanced structure.

3. CONCLUSIONS

It is observed from the results that, all the buildings exceed the permissible limit for drift by about 36% and permissible limit for displacement by about 96%. So there is a need to introduce lateral load resisting systems such as shear wall, bracing system, etc. for high rise building as moment resisting frame of only beams and columns are found to beinsufficient for high rise structures.

The irregular shapes buildings (L, I, T and U) shows poor performance than regular buildings (Rectangular and O); U-Shape building is the worst among all.

The analysis shows that asymmetry in plan affect the performance of a RC building which are subjected to seismic forces. As irregular shape building undergoes more deformation, irregular shape of building must be avoided in high seismic zones, but if it has to be introduced than it must be analyzed and designed by incorporating shear walls, bracings, expansion joint, etc. fulfilling all the necessity checks and conditions carried out as per IS1893(Part-1): 2016.

REFERENCES

[1] Arvindreddy, R.J.Fernandes, “Seismic Analysis of RC Regular and Irregular Frame Structures”, IJERT, Vol.2, Issue: 5, Aug-2015.
[2] Bureau of Indian Standards: IS-1893, part 1 (2016), Criteria for Earthquake Resistant Design of Structures: Part 1 General provisions and Buildings, New Delhi, India.
[3] Bureau of Indian Standards: IS-875, part 1 (1987), Dead Loads on Buildings and Structures, New Delhi, India.
[4] Bureau of Indian Standards: IS-875, part 2 (1987), Imposed Loads on Buildings and Structures, New Delhi, India.
[5] IS 456 (2000): Plain and Reinforced Concrete - Code of Practice [CED 2: Cement and Concrete].
[6] Milind V. Mohod “Effect Of Shape And Plan Configuration On Seismic response Of Structure”International Journal Of Scientific & Technology Research Volume 4.2015.
[7] Mohammed yousuf, P.M. shimpale(2013). Dynamic Analysis of Reinforced Concrete Building with Plan Irregularities. International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 9, September 2013.
[8] Mr. S.Mahesh, Mr. Dr.B.PandurangaRao (2014), ‘Comparison of analysis and design of regular and irregular configuration of multi Story building in various seismic zones and various types of soils using ETABS and STAAD ’, Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 11, Issue 6 (Nov- Dec. 2014).