Sesimic Analysis and Design of Low (G+4), Medium (G+8) & High Rise (G+16) RC Buildings by Using SAP 2000

MULAPAKU GANGA PRASAD REDDY[1], D. YOGESWAR[2]
[1]PG Scholar, Dept of Civil Engineering, Anantha Lakshmi Institute of Technology And Sciences, Itikalapalli, Near S.K University, Ananthapuramu, AP, India.
[2]Assistant Professor, Dept of Civil Engineering, Anantha Lakshmi Institute of Technology And Sciences, Itikalapalli, Near S.K University, Ananthapuramu, AP, India.

Abstract: ***Earthquake load is becoming a great concern in our country as because not a single zone can be designated as earthquake resistant zone. One of the most important aspects is to construct a building structure, which can resist the seismic force efficiently. Designing a structure in such a way that reducing damage during an earthquake makes the structure quite uneconomical, as the earthquake might or might not occur in its life time and is a rare phenomenon. In this project a G+4, G+8 and G+16 RCC framed structure has been analysed and designed using SAP2000 v16. The building is designed as per IS 1893(Part 1):2002 for earthquake forces in seismic zone IV. The main objectives of the project are to compare the variation of maximum displacements and storey drifts for low, medium& high rise structures & Flexure design has been carried out for the selected beam.***

Index Terms: PGA (Peak Ground Acceleration), PGV (Peak Ground Velocity), PGD (Peak Ground Displacement), IRCC.

I. INTRODUCTION

An earthquake is the result of a sudden energy release in the earth's crust that creates seismic waves. The seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Buildings are subjected to ground motion. PGA (Peak Ground Acceleration), PGV (Peak Ground Velocity) PGD (Peak Ground Displacement), Frequency Content, and Duration which play predominant rule in studying the behaviour of buildings under seismic loads. It excludes shock waves caused by nuclear tests, man-made explosions, etc. A list of natural and man-made earthquake sources:

Seismic Sources	
Natural Source	Man-made Source
• Tectonic Earthquakes • Volcanic Earthquakes • Rock Falls/Collapse of Cavity • Microseism	• Controlled Sources (Explosives) • Reservoir Induces Earthquakes • Mining Induces Earthquakes • Cultural noise (Industry, Traffic, etc.)

Fig.1. Seismic Sources.

II. RESPONSE SPECTRUM ANALYSIS

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except for very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following

- Absolute - peak values re added together.
- Square root of the sum of the squares (SRSS)
- Complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes.

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum. In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

III. LITERATURE REVIEW

A. A. Kale, S. A. Rasal, 2017. Author considered four shapes of same area multistorey model and model is analyzed using ETABS under the guideline of IS-875-Part3 & IS1893-2002-Part1. The behavior of 15, 30 & 45 storey building has been studied. Parameters like Story displacement, Story drift, Base shear, Overturning moments, Acceleration and Time period are calculated. Conclusion includes building shape results author concluded that which section is convenient & either seismic or wind effect is critical.

Gauri G. Kakpure, Ashok R. Mundhada, 2016, Reinforced Concrete (RC) building frames are most common types of constructions in urban India. These are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to earthquake. This paper presents a review of the previous work done on multistoried buildings vis-à-vis earthquake analysis. It focuses on static and dynamic analysis of buildings. This paper presents a review of the comparison of static and dynamic analysis multistoried building. Design parameters such as Displacement, Bending moment, Base shear, Storey drift, Torsion, Axial Force were the focus of the study.

S.K. Ahirwar, S.K. Jain and M. M. Pande, 2008, Considerable improvement in earthquake resistant design has been observed in recent past. As a result Indian seismic code IS: 1893 has also been revised in year 2002, after a gap of 18 years. This paper presents the seismic load estimation for multistorey buildings as per IS: 1893-1984 and IS: 1893- 2002 recommendations. Four multistorey RC framed buildings ranging from three storeyed to nine storeyed are considered and analyzed. The process gives a set of five individual analysis sequences for each building and the results are used to compare the seismic response viz. storey shear and base shear computed as per the two versions of seismic code. The seismic forces, computed by IS: 1893- 2002 are found to be significantly higher, the difference varies with structure properties. It is concluded that such study needs to be carried out for individual structure to predict seismic vulnerability of RC framed buildings that were designed using earlier code and due to revisions in the codal provisions may have rendered unsafe.

N.Veerababu, B Anil Kumar**, 2016**, In this study an endeavor has been made to produce reaction spectra utilizing site particular soil parameters for a few destinations in seismic zone V, i.e. Arunachal Pradesh and Meghalaya and the produced reaction spectra is utilized to break down a few structures utilizing business programming STAAD Pro. The impact of soil properties, its sorts and the profundity of soil in the reaction range is talked about. The reaction range is obtained in which the physical properties and time history information of a tremor i.e. North-East seismic tremor of September 10, 1986 which had the greatness of 5.2 is considered. At long last examinations have been made in the middle of the structure outlined by taking IS 1893:2002 reaction spectra under thought with the structure planned by considering the created reaction spectra for different sorts of soil for the seismic zone as far as twisting minute, shear powers and fortification.

IV. METHODOLOGY

There are different methods available for the analysis of framed structures subjected to earthquake loads. The methods of analysis can be broadly classified into the following types.

- Gravity Analysis
- Linear Static Method (Equivalent Static Method)
- Linear Dynamic method (Response Spectrum and Linear Time History Method)
- Non-Linear Static Method (Pushover Analysis)
- Non-Linear Dynamic Method (Non-linear Time History Analysis)

Out of these four methods, Gravity analysis and Linear static method, is considered for the Analysis and Design of G+, G+8 ang G+16 Structure. The equivalent static method is the simplest method of analysis because the forces depend on the code based fundamental period of structures with some empirical modifiers. The design base shear is to be computed as whole, and then it is distributed along the height of the building based on some simple formulae appropriate for buildings with regular distribution of mass and stiffness. The design lateral force obtained at each floor shall then be distributed to individual lateral load resisting elements depending upon the floor diaphragm action. Inherently, equivalent static lateral force analysis is based on the following assumptions,

- Structure is rigid.
- Perfect fixity exit between structure and foundation.
- During ground motion every point on the structure experience same accelerations
- Dominant effect of earthquake is equivalent to horizontal force of varying magnitude over the height.
- Approximately determines the total horizontal force (Base shear) on the structure

However, during an earthquake structure does not remain rigid, it deflects, and thus base shear is disturbed along the height. Following are the major steps in determining the seismic forces:

Step-1: Depending on the location of the building site, identify the seismic zone and assign Zone factor (Z).

- Use Table 2 along with Seismic zones map or Annex of IS-1893 (2002).

Step-2: Compute the seismic weight of the building (W).

- As per Clause 7.4.2, IS-1893 (2002) – Seismic weight of floors.
- As per Clause 7.4.3, IS-1893 (2002) – Seismic weight of the building.

Step-3: Compute the natural period of the building (Ta).

- As per Clause 7.6.1 or Clause 7.6.2, IS-1893 (2002), as the case may be.

Step-4: Obtain the data pertaining to type of soil conditions of foundation of the building.

- Assign type, I for hard soil, II for medium soil & III for soft soil.

Step-5: Using Ta and soil type (I / II / III), compute the average spectral acceleration $\frac{S_a}{g}$

- Use Figure 2 or corresponding table of IS-1893 (2002), to compute a $\frac{S_a}{g}$.

Step-6: Assign the value of importance factor (I) depending on occupancy and/or functionality of structure.

- As per Clause 7.2 and Table 6 of IS-1893 (2002),

Step-7: Assign the values of response reduction factor (R) depending on type of structure.

- As per Clause 7.2 and Table 7 of IS-1893 (2002)

Step-8: Knowing Z, $\frac{S_a}{g}$, R and I compute design horizontal acceleration coefficient (Ah) using therelationship, $A_h = \frac{Z}{2}\frac{I}{R}\frac{S_a}{g}$ [Clause 6.4.2, IS-1893 (2002)].

Step-9: Using Ah and W compute design seismic base shear (VB), from $V_B = A_h W$[Clause7.5.3, IS-1893 (2002)].

Step-10: Compute design lateral force (Q_i) of i^{th} floor by distributing the design seismic base shear (V_B) as per the expression, $Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$ [Clause 7.7.1, IS-1893 (2002)].

In our project Base Shear i.e., Vb is calculated by the software's. Above procedure is for manual calculation

V. MODELLING

In the present study, analysis of G+4, G+8 and G+16 building in most severs zone for earthquake forces is carried out.3D model is prepared inSAP2000. The seismic analysis should be carried out for the buildings that have lack of resistance to earthquake forces. Seismic analysis will consider dynamic effects hence the exact analysis sometimes become complex. However for simple regular structures equivalent linear static analysis is sufficient one.. Linear static analysis will be carried out for the building as specified by code IS 1893-2002 (part1).

A. Plan And Elevation
Plan of RC Frame Considered:

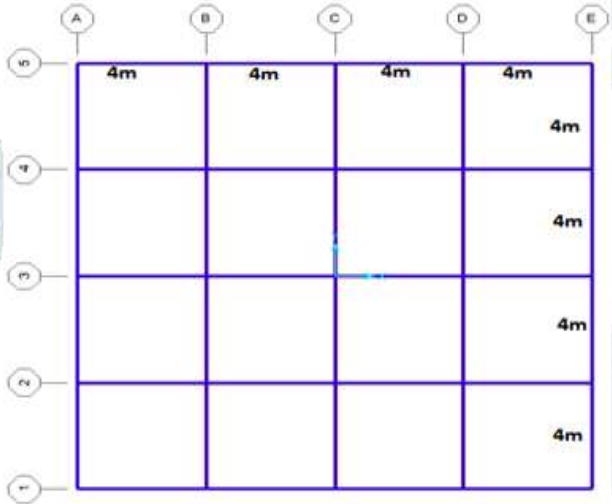

Fig.2. Plan.

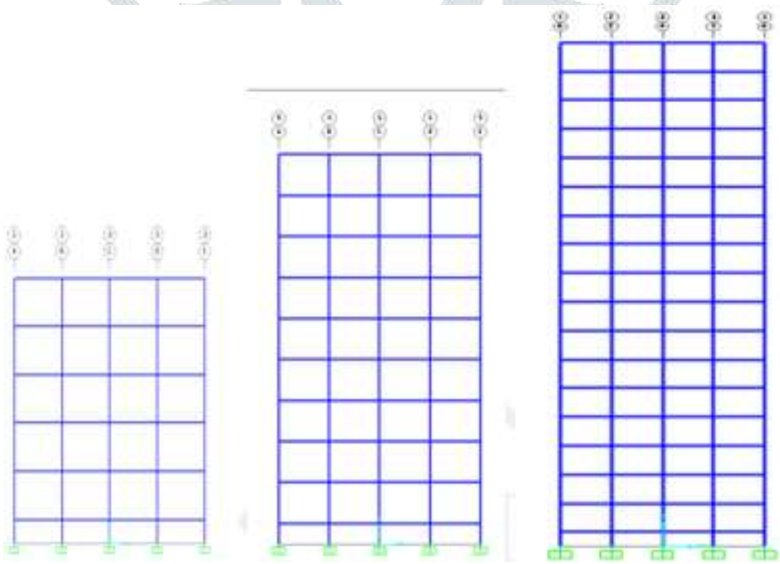

Fig.3. Elevation of G+4, G+8, G+16 RC Structure.

TABLE I: Design Considerations

Model	Gravity Load Building	
	Beam	Column
G+4 RCC structure	230x300mm	350x350mm
G+8 RCC structure	230x450mm	450x450mm
G+16 RCC structure	230x550mm	550x550mm

VI. RESULTS AND DISCUSSIONS

A. Comparison Of Storey Displacements And Drifts

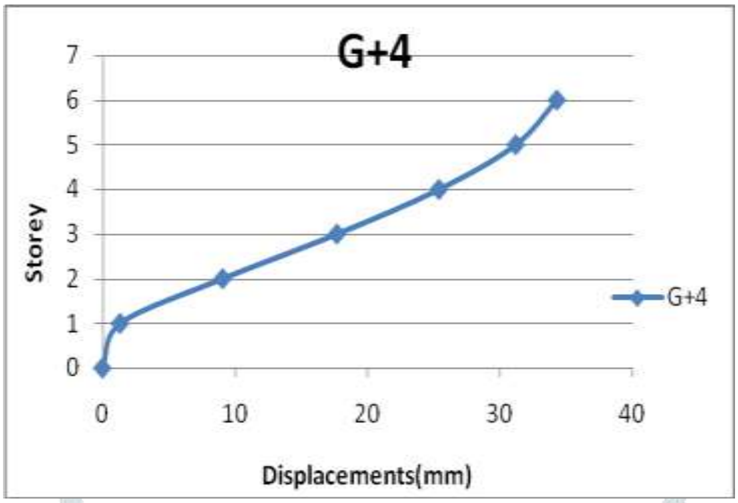

Fig.4.

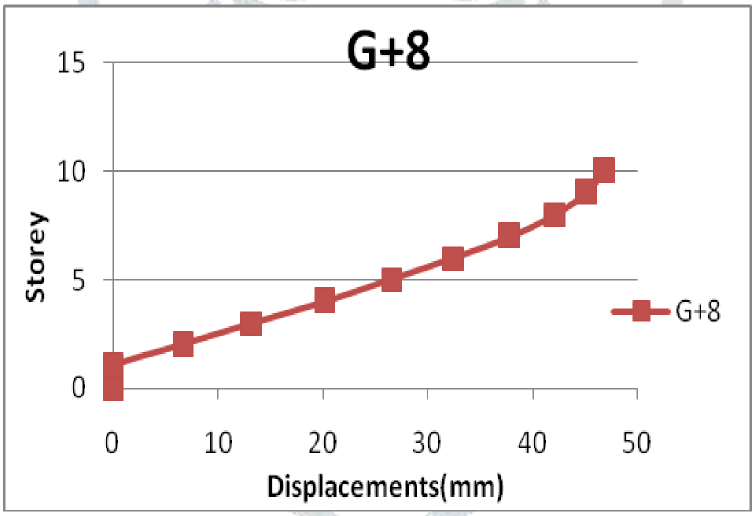

Fig.5.

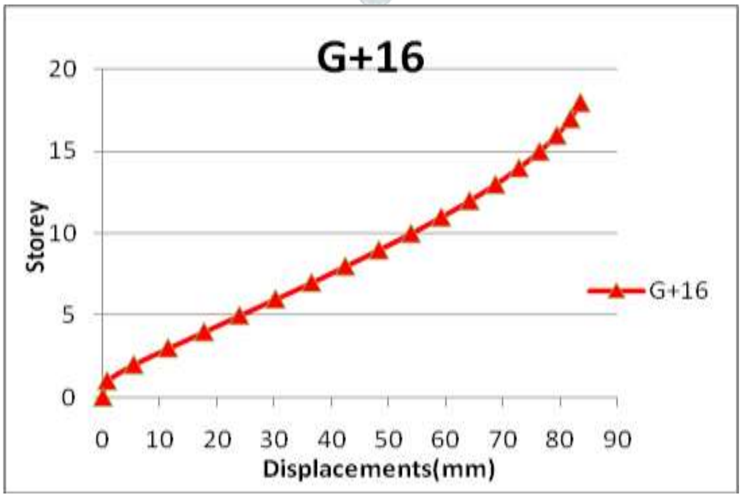

Fig.6.

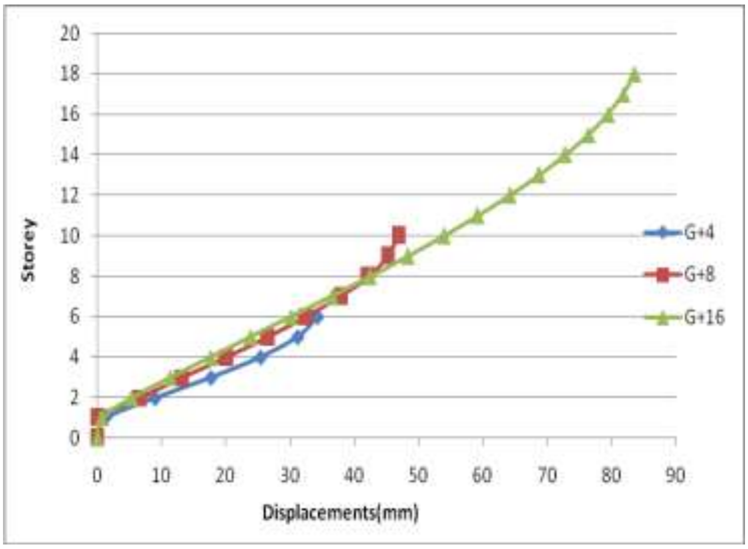

Fig.7. Comparison of Displacements.

From the above results we can conclude that as height increases displacements also increases. The maximum displacement observed for G+4 is 34.3mm, For G+8 is 46.9mm and foe G+16 is 83.54mm.

B. Comparison Of Inter-Storey Drifts

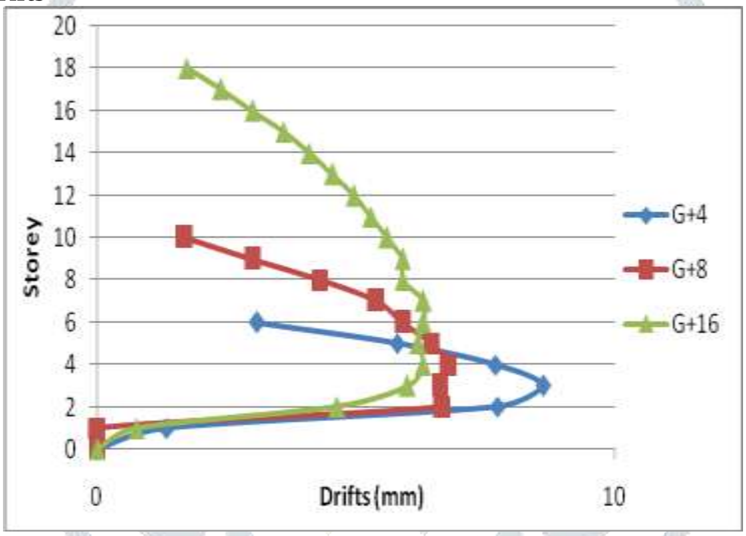

Fig.8. Comparison of Drifts.

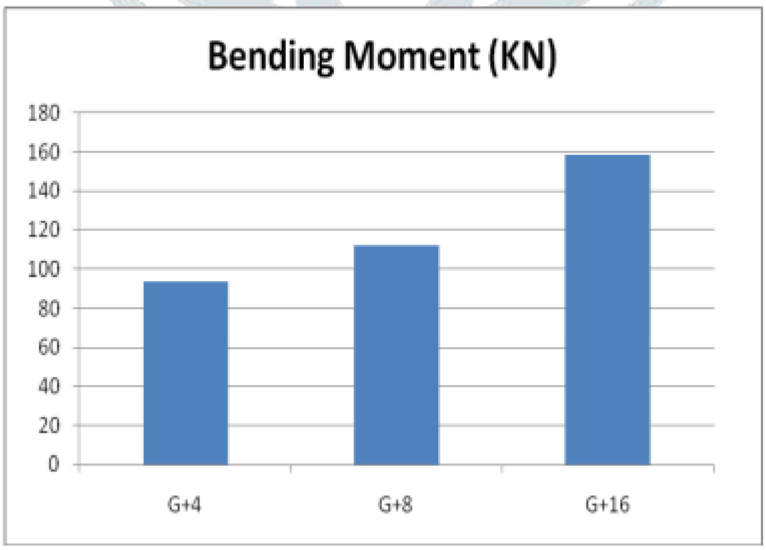

Fig.9. Comparison of Bending Moments for Beam.

C. Bending Moments, Shear Forces And Axial Forces For Critical Beam & Column

The end moments and end shears for basic load cases obtained from computer analysis are given in Tables

TABLE II: Beam and Column Forces

Beam	G+4	G+8	G+16
Bending Moment (Mx)	93.6 kN-m	112 kN-m	158.4 kN-m
Shear Force	97 kN	137.718 kN	154.1 kN
Column Axial Force	1815.09 kN	2356kN	4236 kN

From the above results, a variation between the beam and column forces has been observed. Increase in forces is due to the increase in loads.

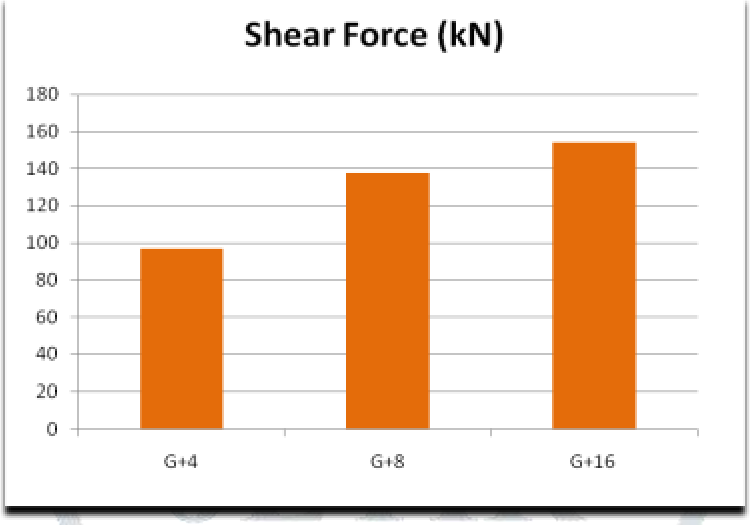

Fig.10. Comparison of Shear Force for Beams.

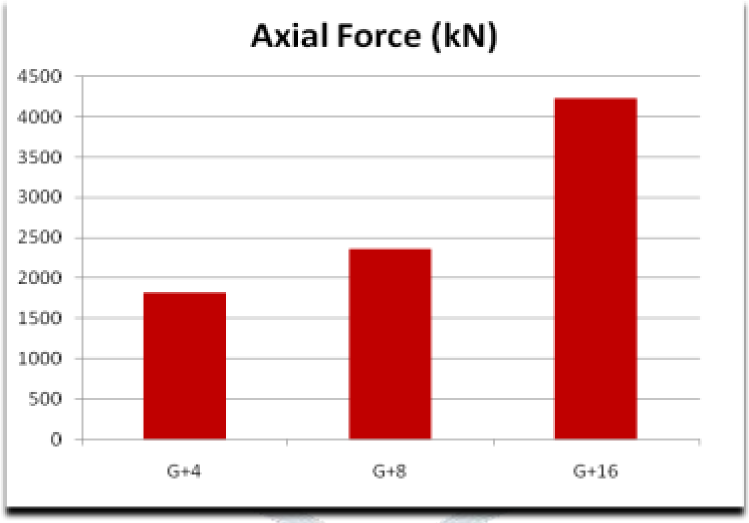

Fig.11. Comparison of Axial Forces for Columns.

VII. CONCLUSIONS

In the present study, G+4, G+8 and G+16 building has been modelled and designed by using Equivalent Static method using ETABS software. The dead load, live load and earthquake loads are calculated using IS: 456-2000 and IS 1893: 2002. Concrete grade M25 and HYSD bars Fe415. Originally, the building was designed without earthquake loads as per IS456:2000. Then building is designed considering the earthquake loads as per IS1893: 2002. The following conclusions were drawn at the end of the study:

- As height increases displacements also increases. The maximum displacement observed for G+4 is 34.3mm, For G+8 is 46.9mm and foe G+16 is 83.54mm.
- The maximum drift for G+4 is 8.62 mm in first floor, G+8 is 6.8mm in second floor and G+16 is 6.4mm in fourth floor.
- Variation between the beam and column forces has been observed. Therefore Increase in forces is due to the increase in loads.

VIII. REFERENCES

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