ANALYTICAL BEHAVIOUR OF RAMMED EARTH BUILDING USING SAP2000

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ABSTRACT. Rammed earth is one of the oldest earthen construction technique practiced worldwide. These types of structures are popular due to its low embodied energy, cost effective, sustainability and environment friendly nature. The present paper deals with the analytical study of rammed earth building using SAP2000. The paper mainly explores the behaviour of rammed earth building under different intensity of earthquake for different seismic zones. The study suggests that the rammed earth buildings under zone V need more attention at the corner joints which is the weakest point for these types of structures. Rather than that, this paper deals with the stress variation, joint displacements, joint reactions and base reactions on walls on applying different load combinations.

Keywords: Rammed earth, earthen techniques, seismic zone, corner joining.

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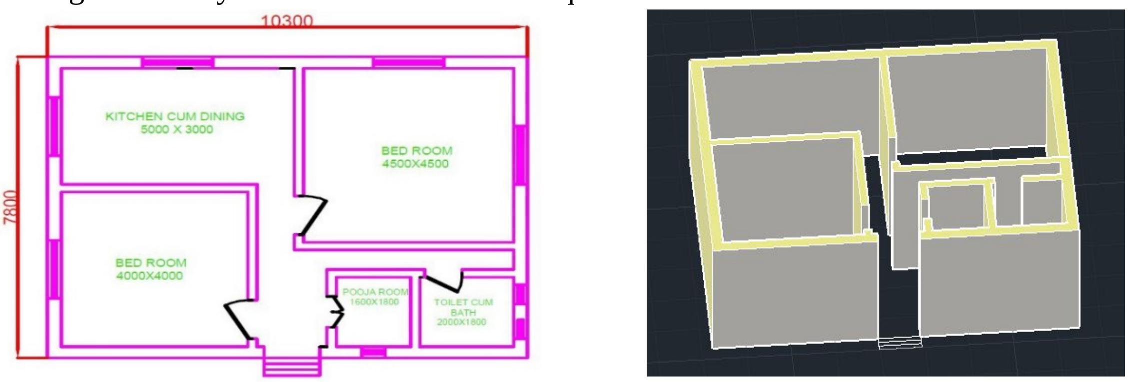
INTRODUCTION

Earth constructions are used worldwide both in ancient and contemporary buildings. Rammed earth is one of the oldest earthen techniques used in worldwide. Recently many researcher research about the benefit of the techniques experimentally as well as analytically (Keable 1996; Blondet *et al.*, 2004; Jayasinghe and Kamaladasa, 2007; Bui et.al., 2014; Miccoli et.al., 2014; Tripura and Singh, 2014 etc.). Portugal earth as a construction material is unknown to most people even though there is a growing interest both to recover this heritage and for the environment, wakening ecological minds and leading to a rebirth of this material. Presently around 30% of the world population lives in earth constructions. Even though the earth building process is one of the most ancient traditional methods, based on empirical procedures and widespread all over the world, the present procedures are an evolution of the ancestral methods in which its potential and most of its properties remain insufficiently developed and researched. The lack of specific education of the technicians from this area and the scarcity of professional courses allowing an updating of knowledge are barriers to conquer. It is therefore crucial to understand the construction procedures to properly design this type of structure, providing it with an adequate geometry and compatible strengthening measures. It is also important to understand the main causes of degradation to minimize their effects. This type of construction has a low mechanical strength when subjected to various actions, namely seismic, and shows physical degradation over time, mostly due to the action of water. These limitations need to be dealt with by improving the raw material properties and adopting adequate constructive solutions. This paper presents some strengthening solutions checking on their viability and pointing out the most adequate and feasible geometry for the constructions.

ANALYSIS OF SINGLE STOREY BUILDING USING SAP 2000 SOFTWARE

The modelling of the building plan is done in AutoCAD software and center to center distance are calculated for modelling in SAP 2000 software. Plan and of 3D model of building is shown in figure 1. Modelling of building in SAP 2000 is done using grids. Walls are created using shell and are assigned with property of cement stabilized rammed earth. After assigning the material and section properties different type of loads were assigned. Building were analyzed for the different earthquake zones.



(a) (b)

Figure 1 (a) Plan (b) 3D model.

VARIATION OF STRESSES IN WALLS AND ROOF IN DIFFERENT SEISMIC ZONE

On performing the analysis after assigning the meshes in walls and slabs the wall as well as whole building structure were selected and observed the stress variation in each elements of building structure for the different seismic zones. According to IS 1893-2002 the zone factor is 0.1 for seismic zone II. On applying factored load combination of dead load and earthquake load in x and y direction and obtained the maximum tensile and compressive stress equals to 116.03kN/m^2 and 24.5kN/m^2 respectively. Similarly, for seismic zones III, IV and V the zone factors are 0.16, 0.24 and 0.36 respectively. The maximum tensile stresses for zone III, IV and V are185.6 kN/m^2, 278.4 kN/m^2, 417.7 kN/m^2 and compressive stresses are 24.58 kN/m^2, 39.325 kN/m^2, 88.5 kN/m^2 respectively. From above observation it can say that value of tensile as well as compressive stress increases with increase in zone factor. The variation in stresses with zones are shown Figure 2. Figure 3 shows variation of joint displacements along positive x-direction with increase in height of building for different zones. From above graph we observed that the value of joint displacement along x- direction increases with increase in height of building as well as with increase in severity of seismic zone. Above graph shows the variation of storey drift for different zones. Table 1 shows the results for joint displacements with height for different seismic zone. From figure 4 it can be concluded that as the height of building increases the value of storey drift first increases and then decreases. The calculation of storey drift is done as given below-

$$\text{Storey Drift} = \frac{Difference\ between\ displacement\ of\ two\ consecutive\ joints}{Distance\ between\ joints}$$

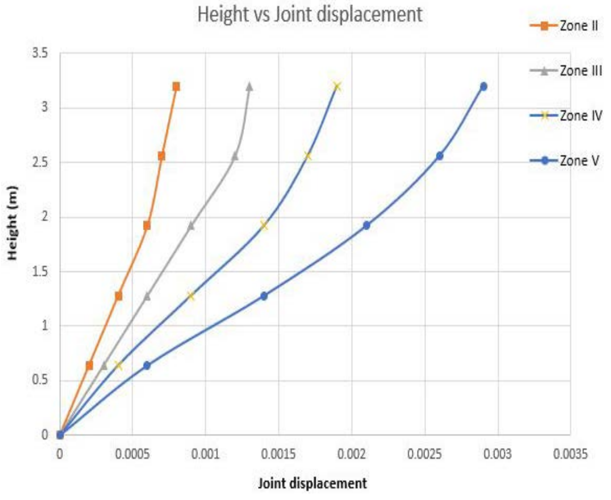


Figure 2 Building height vs. joint displacement.

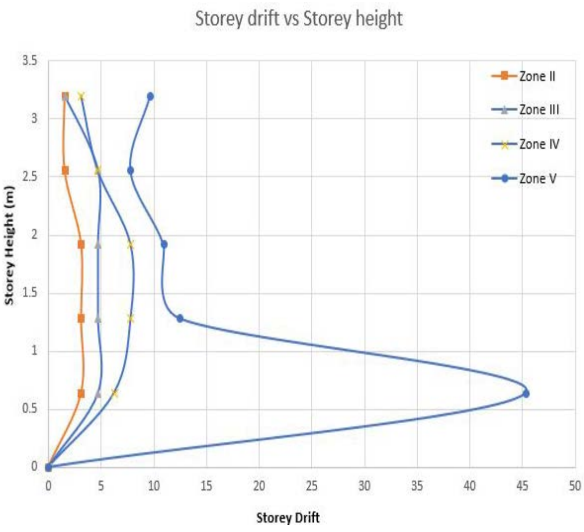


Figure 3 Building height vs. Storey drift.

Table 1 Joint displacements with height for different seismic zone.

	JOINT DISPLACEMENTS			
Height (m)	II	III	IV	V
0	0	0	0	0
0.64	0.0002	0.0003	0.0004	0.0006
1.28	0.0004	0.0006	0.0009	0.0014
1.92	0.0006	0.0009	0.0014	0.0021
2.56	0.0007	0.0012	0.0017	0.0026
3.20	0.0008	0.0013	0.0019	0.0029

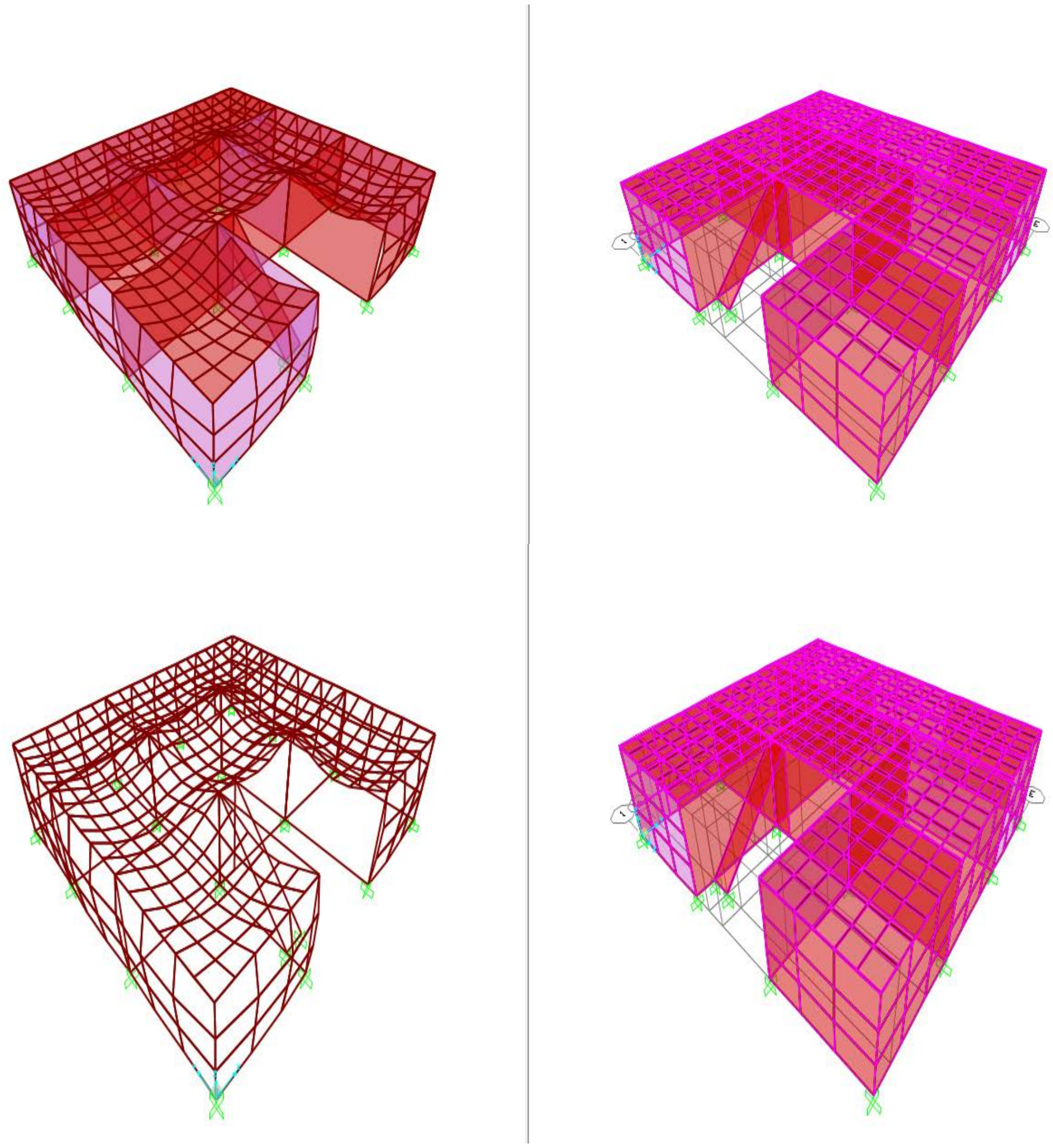


Figure 4 Fill object and mesh object representation of deformed shape.

CONCLUDING REMARKS

In the SAP Analysis result, model frequency, joint reaction, joint displacement, element force and joint force in permissible limit is found out. So, it can conclude that using Rammed earth wall with concrete slab are getting appropriate result and building is capable to resist earthquake load in x and y direction. On basis of analysis available here it has been conclude as follows- Earth construction has lost most of its important as a construction material during last centuries, being replaced by stronger and stiffer materials. However now days, shift of this trend is taking place and an increased demand to use earth as a construction material is noticed. This is due to low energy consumption in constructive cycle and its positive environmental effect. The study presented in this project report showed that properly constructed rammed earth is capable to resist earthquake load as well as live and self-weight of slab. So, based on this study it is advisable to construct Rammed Earth single storey building.

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