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Analysis of Seismic Performance of Rock Block Structures with STAAD Pro

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ABSTRACT
From olden days until now in our construction filed unreinforced masonry blocks of rocks is used as foundation and super structure wall as load bearing structure. In which blocks are stacked, sometimes being mortared with various cements. Ancient civilizations used locally available rocks and cements to construct rock block columns, walls and edifices for residences, temples, fortifications and infrastructure. Monuments still exist as testaments to the high quality construction by historic cultures, despite the seismic and other potentially damaging geo-mechanical disturbances that threaten them. Conceptual failure modes under seismic conditions of rock block structures, observed in the field or the laboratory, are presented. Our proposed work is analytically is carried out with rock block of 1m by 1m with 200 mm rock block under seismic loading to find out the damaged caused by the M_W 6.7 and 6.0 earthquakes on that block subject to dynamic load. Finally graphical output has generated and suggested for safe construction with more seismic load on rock blocks.
Keywords: Rock block structures, Earthquakes, Earthquake observations, to failures.

I INTRODUCTION

Construction of unreinforced masonry is common in various earthquake-prone regions, particularly in developing countries, and rural areas of developed countries. This vulnerable type of construction is susceptible to often devastating damage, as evident from the effects of the 2001 Bhuj, India earthquake (Murty et al. 2002), where 1,200,000 masonry buildings built primarily based on local traditional construction practices, either collapsed or were severely damaged. Buildings constructed with adobe and unreinforced masonry suffered devastating damage in the Bam, Iran 2003 earthquake (Nadim et al. 2004). However, in the 2002 Molise, Italy earthquake post-1850 unreinforced masonry buildings performed worse than medieval and renaissance-age masonry buildings (Decanini et al.2004) indicating that certain methods and materials of construction used in culturally valuable archaeological and monumental structures may have properties that have resisted significant earthquakes. This paper reviews some aspects of the geo-mechanical performance of structures assembled as unreinforced masonry using blocks of rock.

1.1 Some Common Characteristics of Rock Block Structures

A simple grouping of rock block structures can be developed based on the cross-sectional aspect ratio of structures (such as width and thickness to height). Rock block columns are relatively slender with height substantially greater than their width and thickness and include towers, pillars, and obelisks. Rock block walls such as fences, partitions, ramparts, bulwarks, and retaining walls have width of the order of their height, but smaller than the thickness. Rock block edifices have width and thickness similar to, or often substantially greater, than their height and include platforms, ramps, terraced embankments, dams, mounds and pyramids. Edifices are often of imposing appearance or size and, if of unique character, may be considered monuments. The exterior envelopes of rock block edifices or the facing of retaining walls may be composed of artfully fabricated veneers of high-quality rock blocks. The inner cores or backfill may consist of stacked courses of blocks, earth or loose rubble. The contacts between facing blocks and core materials range from dry stacked (no inter-block cement) to partially or fully cemented, although the culturally significant monuments considered in this paper are mortar-free. Facings and interior cores of rock block edifices may be penetrated by openings such as windows, doors, corridors, chambers and stairways, the latter being a feature of monuments such as the pyramids.

II SOME FAILURE MODES OF ROCK BLOCK STRUCTURES

Figure 2.1 show several modes of failure, which have been observed in the laboratory, on sites of culturally significant rock block structures or can be expected for rock block structures subjected to seismic loading. These modes are:

A) Block-on-block sliding of columns: whereas stacked blocks of rocks, that could be for example part of a column of a temple, move relative to each other as a result of seismic excitation and exhibit permanent relative seismic displacement.

B) Bending of a (generally mortared) wall or column during seismic loading as a result of the structural response of the column or the structure that the column supports.

C) Sliding and dislodgement of blocks; that could occur during earthquake loading of the structure that has been exposed to centuries of weathering and erosion.

D) Dislocation of walls due to differential settlement of foundation soils, which could take place under static or seismic conditions. An example of this mode for an Inca wall in Machu Pichu is presented by Wright and Zegarra

E) Loss of strength of loose soil or rubble cores or backfill, and imposition of additional loading on walls; and (**F**)

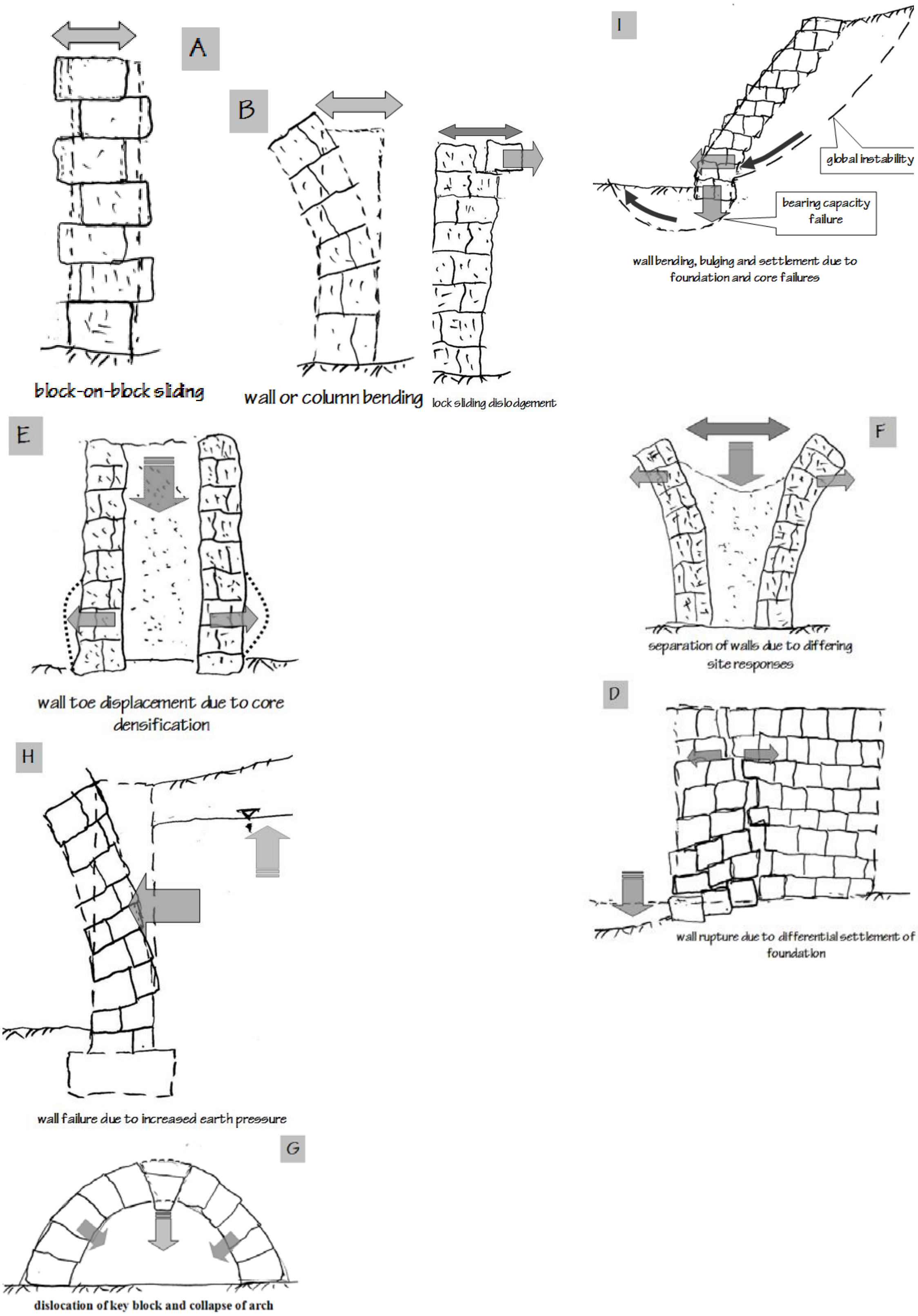

Figure No 2.1 Failure modes of rock block structures

(**F**) separation of block walls due to differing response of fill and exterior walls; Such modes of failure have been observed in shake table tests performed by Meyer et al. (2007) on brick and stone walls.

G) Loss of arch key block and deformation of arch legs. Such failure modes have been observed on Mycenaean underground burial chambers known as "treasuries".

H) Increase in earth pressures of core or backfill, possibly by the elevation of water.

I) Wall deformation due to global instability such as failure of the core or backfill or a failure at the toe due to inadequate bearing capacity of the underlying soils.

J) Raveling, bulging and slumping failures of the outer faces of a rock block edifice, such as those observed at the Hawaiian heiaus described subsequently. Face failure may be progressive: the inclination of the bulges increase until they become over-steepened and collapse, thereby inducing collapse of the face above.(Figure 2.2)

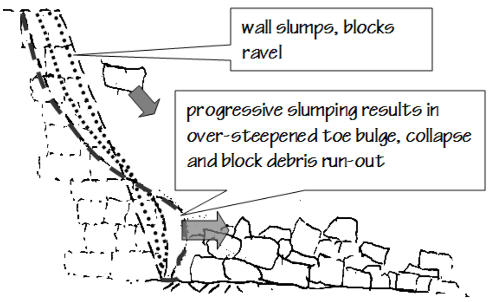

Figure No 2.2 raveling, bulging and slumping of the face of a rock block edifice

There are benefits to considering the apparent similarities between rock block edifices and natural arrangements of rock blocks in rock masses. In-situ blocks in rock masses are bounded by joints, shears, fractures and other discontinuities which range between open apertures or contain infillings ranging through soil-like to strongly mineralize. Loose rock debris is analogous to talus fans or colluviums. Considered in geo-mechanical terms, it can be reasonably expected that rock block edifices may behave under static and dynamic loadings in similar fashion to natural masses of rock and coarse soil. For structures with tightly-packed or layered block arrangements, roughly "circular" failures occur where the failure surfaces negotiate around the boundaries of blocks, with a degree of failure surface roughness dependent on the size of the blocks. For edifices with internal cores composed of loose rubble or soil face slumping or bulging is anticipated. Very steep and high wall faces composed of stacked rocks arranged in columns may topple, much as steeply-jointed slabs of naturally jointed rock topple. Additional analogies between block rock structures and natural rock masses can be conceived. In some cases, it may be advantageous to perform preliminary geo-mechanical analysis of rock block edifices using conventional rock mass characterization schemes, which require field estimates of water conditions; intact rock strength: joint orientations, friction angle, spacing, persistence, roughness and surface conditions. These qualities are estimated by an investigating geological engineer or engineering geologist, often without the benefit of much exploration data from penetrative borings or trenches. The need to work with limited observations is also likely a familiar situation for an investigating archaeologist charged with characterizing a rock block structure without the benefit of intrusive explorations.

III ROCKS AND ITS PROPERTIES

In geology, a **rock** is a naturally occurring solid aggregate of one or more minerals or mineralogist. For example, the common rock, granite, is a combination of the quartz, feldspar and biotite minerals. The Earth's outer solid layer, the lithosphere, is made of rock. Rocks have been used by mankind throughout history. From the Stone Age rocks have been used for tools. The minerals and metals we find in rocks have been essential to human civilization. Three major groups of rocks are defined: igneous, sedimentary, and metamorphic. The scientific study of rocks is called petrology, which is an essential component of geology.

3.1 Rock Masses as Construction Materials:

A rock mass is a material quite different from other structural materials used in civil engineering. It is heterogeneous and quite often discontinuous, but is one of the materials in the earth's crust, which is most, used in man's construction. Ideally, a rock mass is composed of a system of rock blocks and fragments separated by discontinuities forming a material in which all elements behave in mutual dependence as a unit (Matula and Holzer, 1978). The material is characterized by shape and dimensions of rock blocks and fragments, by their mutual arrangement within the rock mass, as well as by joint characteristics such as joint wall conditions and possible filling (Figure 3.1)

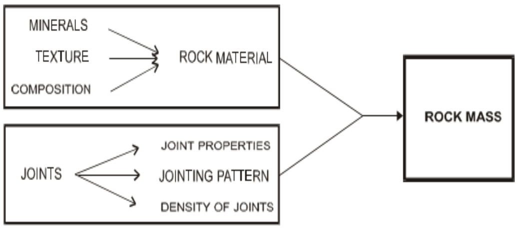

Figure 3.1 the Main Features Constituting a Rock Mass

Table 3.1 Basic Elements And Relevant Considered Areas (Based On Natau,1990)

BASIC ELEMENT	SIZE RANGE	STRUCTURES	CONSIDERED AREA
Crystal lattice	Angstrom size (10^{-7} mm)	Micro structures	Electron microscope
Mineral grain	µm - cm	Grain structures in rock	Microscope, hand piece, test sample of rock
Rock material	cm - 10 m	Massive rock	Hand piece, stone ornaments, building stone, test of rock samples.
Jointed rock (composed of 'bricks')	cm - 10 m	Joint pattern, rock mass	Foundations, small underground structures, test samples of rock masses, test pits/adits
Geological-tectonical units	10 m - km	Rock mass volumes between large faults	Slopes, tunnels, large underground struc-tures, mines (geological maps and sections)
Geological-tectonical large size units	Several km	Regional plates	Oil reservoirs, (general geological maps and sections)

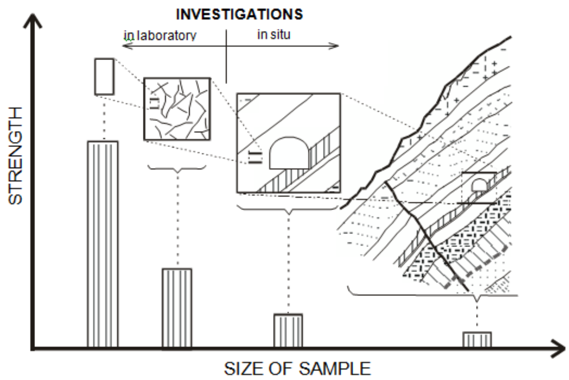

Figure 3.2 The Scale Factor Of Rock Masses And The Variation In Strength Of The Material On The Size Of The 'Sample' Involved

Other special features in a rock mass and its utilization in contrast to other construction materials are:

- The size or volume of the material involved, see Figure 3-2 and Table 3-1,
- The structure and composition of the material,
- The many construction and utilization purposes of it, see Table 3-2, and
- The difficulties in measuring the quality of the material.

Table 3.2 Main Types Of Works Connected To Rocks And Rock Masses

TYPE	ACTUAL PROCESS OR USE
Treatment of rocks	- drilling (small holes) - boring (TBM boring, shaft reaming) *) - blasting *) - fragmentation *) - crushing - grinding - cutting *)
Application of rocks	- rock aggregate for concrete etc. - rock fill - building stone
Utilization of rock masses	- in underground excavations (tunnels, caverns, shafts) *) - in surface cuts/slopes/portals *)
Construction works in rock masses	- excavation works - rock support *) - water sealing

These factors imply that other methods of data acquisition are used, and that other procedures in the use of these data for construction purposes have been developed. Thus, the material properties of rock masses are not measured but estimated from descriptions and indirect tests. The stress is not applied by the engineering but is already present; the construction, however, leads to stress changes.In the remainder of this chapter the main features of the rock mass and their effect on its behavior related to rock construction are briefly outlined.

3.2 Rocks And Their Main Features:

Geologists use a classification, which reflects the origin, formation and history of a rock rather than its potential mechanical performance. The rock names are defined and used not as a result of the strength properties, but according to the abundance, texture and types of the minerals involved, in addition to mode of formation, degree of metamorphism, etc. According to Franklin (1970) there are over 2000 names available for the igneous rocks that comprise about 25% of the earth's crust, in contrast to the greater abundance of mud rocks (35%) for which only a handful of terms exist; yet the mud rocks show a much wider variation in mechanical behavior.

Fresh Rocks

Each particular rock type is characterized by its minerals, texture fabric, bonding strength and macro and micro structure, see Fig. 4-3.

Igneous Rocks

Igneous rocks tend to be massive rocks of generally high strength. Their minerals are of a dense inter-fingering nature resulting in only slight, if any, directional differences in mechanical properties of the rock. These rocks constitute few problems in rock construction when fresh.

Sedimentary Rocks

Sedimentary rocks constitute the greatest variation in strength and behavior. The minerals of these rocks are usually softer and their assemblage is generally weaker than the igneous rocks. In these rocks the minerals are not interlocking but are cemented together with inter-granular matrix material. Sedimentary rocks usually contain bedding and lamination or other sedimentation structures and, therefore, may exhibit significant anisotropy in physical properties depending upon the degree of their development. Of this group, argillaceous and arenaceous rocks are usually the most strongly anisotropic. Some of the rocks are not stable in the long term, as for example mud rocks, which are susceptible to slaking and swelling. This group of rocks therefore creates many problems and challenges in rock construction.

Metamorphic Rocks

Metamorphic rocks show a great variety in structure and composition and properties. The metamorphism has often resulted in hard minerals and high intact rock strength; however, the preferred orientation of platy (sheet) minerals due to shearing movements results in considerable directional differences in mechanical properties. Particularly the micaceous and chloritic schists are generally the most outstanding with respect to anisotropy.

3.3 Influences from Some Minerals:

Certain elastic and anisotropic minerals like mica, chlorite, amphiboles, and pyroxenes may highly influence the mechanical properties of the rocks in which they occur (Selmer-Olsen, 1964). Parallel orientation of these minerals is often found in sedimentary and regional metamorphic rocks in which weakness planes may occur along layers of these flaky minerals. Where mica and chlorite occur in continuous layers their effect on rock behavior is strongly increased. Thus, mica schist's and often phyllites have strong anisotropic mechanical properties of great importance in rock construction. Also other sheet minerals like serpentine, talc, and graphite reduce the strength of rocks due to easy sliding along the cleavage surfaces see Figure 3-3.

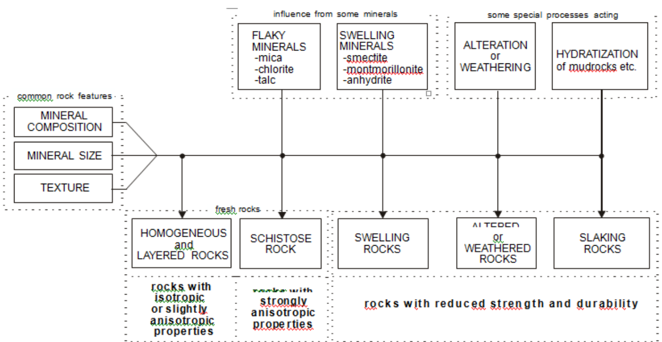

Figure 3.3 The Main Variables Influencing Rock Properties And Behavior

3.4 The Effect of Alteration and Weathering:

The processes of alteration and weathering with deterioration of the rock material have reducing effect on the strength and deformation properties of rocks, and may completely change the mechanical properties and behavior of rocks (refer to Fig. 2-3). For most rocks, except for the weaker types, these processes are likely to have great influence on engineering behavior of rock masses. Hence, the description and characterization of rock masses should pay particular attention to such features.

3.5 Geological Names and Mechanical Properties of Rocks:

Rocks that differ in mineral composition, porosity, cementation, consolidation, texture and structural anisotropy can be expected to have different strength and deformation properties. Geological nomenclature of rocks emphasizes mainly solid constituents, whereas from the engineer's point of view, pores, defects and anisotropy are of greater mechanical significance (Franklin, 1970). For each type of rocks the mechanical properties vary within the same rock name.

3.6 Discontinuities in Rock:

Any structural or geological feature that changes or alters the homogeneity of a rock mass can be considered as a discontinuity. Discontinuities constitute a tremendous range, from structures which are sometimes thousands of meters in extent down to - per definition - mm size, see Figure 3-4.

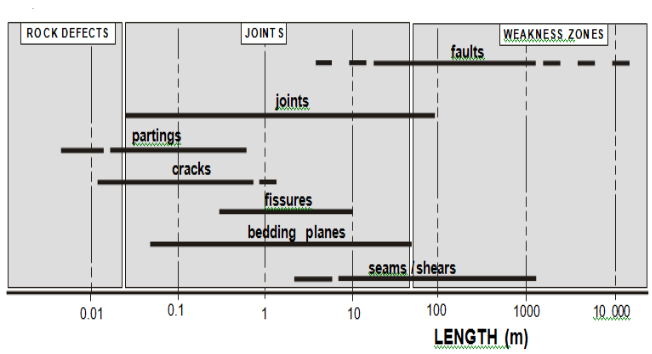

Figure 3.4 The Main Types Of Discontinuities According To Size

The different types, such as faults, dykes, bedding planes, tension cracks, etc. have completely different engineering significance (Piteau, 1970). The roughness, nature of their contacts, degree and nature of weathering, type and amount of gouge and susceptibility to ground water flow will vary greatly from one type of discontinuity to another since their cause; age and history of development are fundamentally different. The effect on rock masses due to these localized discontinuities varies considerably over any given region depending on structure, composition and type of discontinuity.

The great influence of discontinuities upon rock mass behavior calls for special attention to these features when characterizing rock masses for practical applications. Joints and faults have numerous variations in the earth's crust, this is probably the main reason that it has been so difficult to carry out common observation and description methods.

3.7 Faults

Faults are breaks along which there has been displacement of the sides relative to one another parallel to the break. Minor faults range in thickness from decimeter to meter; major faults from several meters to, occasionally, hundreds of meters.

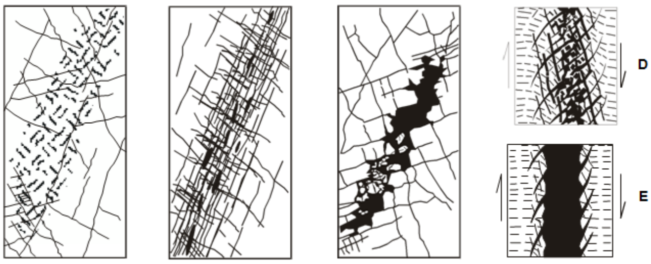

Fig: No 4.5 Sketches of Some Types of Weakness Zones

3.8 Joints and Their Main Features:

Joints are the most commonly developed of all structures in the earth's crust, since they are found in all competent rocks exposed at the surface. Yet, despite the fact that they are so common and have been studied widely, they are perhaps the most difficult of all structures to analyse. The analytical difficulty is caused by the number of fundamental characteristics of these structures

IV ANALYSIS WITH SOFTWARE

4.1 About Staad Pro:

STAAD or (STAAD.Pro) is a structural analysis and design computer program originally developed by Research Engineers International in Yorba Linda, CA. In late 2005, Research Engineer International was bought by Bentley Systems. An older version called Staad-III for windows is used by Iowa State University for educational purposes for civil and structural engineers. The commercial version STAAD.Pro is one of the most widely used structural analysis and design software. It supports several steel, concrete and timber design codes.It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric non linear analysis or a buckling analysis. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.In recent years it has become part of integrated structural analysis and design solutions mainly using an exposed API called Open STAAD to access and drive the program using an VB macro system included in the application or other by including Open STAAD functionality in applications that themselves include suitable programmable macro systems. Additionally STAAD.Pro has added direct links to applications such as RAM Connection and STAAD. Foundation to provide engineers working with those applications which handle design post processing not handled by STAAD.Pro itself. Another form of integration supported by STAAD.Pro is the analysis schema of the CIMsteel Integration Standard, version 2 commonly known as CIS/2 and used by a number modeling and analysis applications.Consider rock block of 1m by 1m with thickness of 500mm subjected to seismic loading of 6.5hertz of stress which acting on all surface of the block. Finally we find out the safe condition for block to retaining the seismic load for construction application.Figure 4.1 to 4.13 shows the analysis diagrams.

4.2 Analysis (INPUT & OUTPUT) graphically:

STAAD.Pro Report

To:	From:			
Copy to:	Date:	14/05/2013 09:33:00	Ref:	ca/ Document1

Job Information

	Engineer	Checked	Approved
Name:			
Date:	14-May-13		

Structure Type SPACE FRAME

Number of Nodes 8 Highest Node

Number of Solids	1	Highest Solid 13
Number of Basic Load Cases		1
Number of Combination Load Cases		0

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	
Primary	1	LOAD CASE 1

Nodes

Node	X (m)	Y (m)	Z (m)
1	0.000	0.000	0.000
2	1.000	0.000	0.000
3	0.000	1.000	0.000
4	1.000	1.000	0.000
5	0.000	0.000	0.500
6	1.000	0.000	0.500
7	0.000	1.000	0.500
8	1.000	1.000	0.500

Solids

Solid	Node A	Node B	Node C	Node D	Node E	Node F	Node G	Node H
13	3	7	5	1	4	8	6	2

Materials

Mat	Name	E (kN/mm^2)	□	Density (kg/m^3)	□ (1/°K)
3	STEEL	205.000	0.300	7.83E 3	12E -6
4	ALUMINUM	68.948	0.330	2.71E 3	23E -6
5	CONCRETE	21.718	0.170	2.4E 3	10E -6

Supports

Node	X (kN/mm)	Y (kN/mm)	Z (kN/mm)	rX (kN-m/deg)	rY (kN-m/deg)	rZ (kN-m/deg)
1	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
2	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
5	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
6	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed

Basic Load Cases

Number	Name
1	LOAD CASE 1

Combination Load Cases

There is no data of this type.

Load Generators

There is no data of this type.

Loading

There is no data of this type.

Node Displacements

Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
1	1:LOAD CASE 1	0.000	0.000	0.000	0.000	0.00	0.00	0.000
2	1:LOAD CASE 1	0.000	0.000	0.000	0.000	0.00	0.00	0.000
3	1:LOAD CASE 1	2.81E 3	1.34E 3	146.9	3.12E 3	0.00	0.00	0.000
4	1:LOAD CASE 1	2.81E 3	-1.34E 3	-146.9	3.12E 3	0.00	0.00	0.000
5	1:LOAD CASE 1	0.000	0.000	0.000	0.000	0.00	0.00	0.000
6	1:LOAD CASE 1	0.000	0.000	0.000	0.000	0.00	0.00	0.000
7	1:LOAD CASE 1	2.81E 3	1.34E 3	-146.9	3.12E 3	0.00	0.00	0.000
8	1:LOAD CASE 1	2.81E 3	-1.34E 3	146.9	3.12E 3	0.00	0.00	0.000

Node Displacement Summary

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	rZ (rad)
Max X	3	1:Load Case 1	**2.81 E 3**	1.34 E 3	146.974	3.12 E 3	0.000	0.000	0.000
Min X	1	1:Load Case 1	**0.000**	0.000	0.000	0.000	0.000	0.000	0.000
Max Y	3	1:Load Case 1	2.81 E 3	**1.34 E 3**	146.974	3.12 E 3	0.000	0.000	0.000

Min Y	4	1:Load Case 1	2.81E 3	**-1.34E 3**	-146.974	3.12E 3	0.000	0.000	0.000
Max Z	3	1:Load Case 1	2.81E 3	1.34E 3	**146.974**	3.12E 3	0.000	0.000	0.000
Min Z	4	1:Load Case 1	2.81E 3	-1.34E 3	**-146.974**	3.12E 3	0.000	0.000	0.000
Max rX	1	1:Load Case 1	0.000	0.000	0.000	0.000	**0.000**	0.000	0.000
Min rX	1	1:Load Case 1	0.000	0.000	0.000	0.000	**0.000**	0.000	0.000
Max rY	1	1:Load Case 1	0.000	0.000	0.000	0.000	0.000	**0.000**	0.000
Min rY	1	1:Load Case 1	0.000	0.000	0.000	0.000	0.000	**0.000**	0.000
Max rZ	1	1:Load Case 1	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Min rZ	1	1:Load Case 1	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**
Max Rst	3	1:Load Case 1	2.81E 3	1.34E 3	146.974	**3.12E 3**	0.000	0.000	0.000

Solid Centre Stresses

		Normal			Shear		
Solid	L/C	Sxx (N/mm²)	Syy (N/mm²)	Szz (N/mm²)	Sxy (N/mm²)	Syz (N/mm²)	Szx (N/mm²)
13	1:LOAD	-0.000	-0.000	-0.000	0.001	0.00	-0.000

Solid Centre Stress Summary

			Normal			Shear		
	Solid	L/C	Sxx (N/mm²)	Syy (N/mm²)	Szz (N/mm²)	Sxy (N/mm²)	Syz (N/mm²)	Szx (N/mm²)
Max Fx	13	1:LOAD CASE 1	**-0.00**	-0.000	-0.000	0.001	0.000	-0.000
Max Fy	13	1:LOAD CASE 1	-0.00	**-0.000**	-0.000	0.001	0.000	-0.000
Max Fz	13	1:LOAD CASE 1	-0.00	-0.000	**-0.000**	0.001	0.000	-0.000
Max Sxy	13	1:LOAD	-0.00	-0.000	-0.000	**0.001**	0.000	-0.000
Max Syz	13	1:LOAD CASE 1	-0.00	-0.000	-0.000	0.001	**0.000**	-0.000
Max Szx	13	1:LOAD CASE 1	-0.00	-0.000	-0.000	0.001	0.000	**-0.000**

Solid Centre Principal Stresses

There is no data of this type.

Solid Centre Principal Stress Summary

			Principal			Von Mis	Direction S1			Direction S2		
	Solid	L/C	S1 (N/mm²)	S2 (N/mm²)	S3 (N/mm²)	Von Mis (N/mm²)	X	Y	Z	X	Y	Z
Max S1	13	1:LOA	**0.00**	-0.000	-0.00	0.001	0.707	0	0.	0	0	1
Max S2	13	1:LOA	0.00	**-0.000**	-0.00	0.001	0.707	0	0.	0	0	1
Max S3	13	1:LOA	0.00	-0.000	**-0.00**	0.001	0.707	0	0.	0	0	1
Max Von	13	1:LOA	0.00	-0.000	-0.00	**0.001**	0.707	0	0.	0	0	1

Solid Corner Stresses

There is no data of this type.

Solid Corner Stress Summary

				Normal			Shear		
	Solid	Node	L/C	Sxx (N/Mm²)	Syy (N/Mm²)	Szz (N/Mm²)	Sxy (N/Mm²)	Syz (N/Mm²)	Szx (N/Mm²)
Max Fx	13	3	1:LOAD CASE 1	**-0.001**	0.001	-0.001	0.001	0.000	-0.000
Max Fy	13	5	1:LOAD CASE 1	0.001	**0.004**	0.002	0.001	-0.000	-0.000
Max Fz	13	5	1:LOAD CASE 1	0.001	0.004	**0.002**	0.001	-0.000	-0.000

Max Sxy	13	3	1:LOAD CASE 1	-0.001	0.001	-0.001	**0.001**	0.000	-0.000
Max Syz	13	3	1:LOAD CASE 1	-0.001	0.001	-0.001	0.001	**0.000**	-0.000
Max Szx	13	3	1:LOAD CASE 1	-0.001	0.001	-0.001	0.001	0.000	**-0.000**

Solid Corner Principal Stresses

There is no data of this type.

Solid Corner Principal Stress Summary

	Solid	Node	L/C	Principal S1 (N/mm^2)	S2 (N/mm^2)	S3 (N/mm^2)	Von Mis (N/mm^2)	Direction S1 X	Y
Max S1	1	5	1:LOAD CASE 1	**0.004**	0.002	0.001	0.002	0.290	0.955
Max S2	1	5	1:LOAD CASE 1	0.004	**0.002**	0.001	0.002	0.290	0.955
Max S3	1	6	1:LOAD CASE 1	-0.001	-0.002	**-0.004**	0.002	0.957	0.288
Max Von	1	3	1:LOAD CASE 1	0.001	-0.001	-0.002	**0.003**	0.289	0.957

Reactions

Node	L/C	Horizontal FX (kN)	Vertical FY (kN)	Horizontal FZ (kN)	Moment MX (kNm)	MY (kNm)	MZ (kNm)
1	1:LOAD CASE 1	-0.095	-0.190	-0.097	0.00	0.000	0.000
2	1:LOAD CASE 1	-0.095	0.190	0.097	0.00	0.000	0.000
5	1:LOAD CASE 1	-0.095	-0.190	0.097	0.00	0.000	0.000
6	1:LOAD CASE 1	-0.095	0.190	-0.097	0.00	0.000	0.000

Reaction Summary

	Node	L/C	Horizontal FX (kN)	Vertical FY (kN)	Horizontal FZ (kN)	Moment MX (kNm)	MY (kNm)	MZ (kNm)
Max FX	1	1:LOAD CASE 1	**-0.095**	-0.190	-0.097	0.000	0.000	0.000
Min FX	1	1:LOAD CASE 1	**-0.095**	-0.190	-0.097	0.000	0.000	0.000
Max FY	2	1:LOAD CASE 1	-0.095	**0.190**	0.097	0.000	0.000	0.000
Min FY	1	1:LOAD CASE 1	-0.095	**-0.190**	-0.097	0.000	0.000	0.000
Max FZ	2	1:LOAD CASE 1	-0.095	0.190	**0.097**	0.000	0.000	0.000
Min FZ	1	1:LOAD CASE 1	-0.095	-0.190	**-0.097**	0.000	0.000	0.000
Max MX	1	1:LOAD CASE 1	-0.095	-0.190	-0.097	**0.000**	0.000	0.000
Min MX	1	1:LOAD CASE 1	-0.095	-0.190	-0.097	**0.000**	0.000	0.000
Max MY	1	1:LOAD CASE 1	-0.095	-0.190	-0.097	0.000	**0.000**	0.000
Min MY	1	1:LOAD CASE 1	-0.095	-0.190	-0.097	0.000	**0.000**	0.000
Max MZ	1	1:LOAD CASE 1	-0.095	-0.190	-0.097	0.000	0.000	**0.000**
Min MZ	1	1:LOAD CASE 1	-0.095	-0.190	-0.097	0.000	0.000	**0.000**

Reaction Envelope

Node	Env	Horizontal FX (kN)	Vertical FY (kN)	Horizontal FZ (kN)	Moment MX (kNm)	MY (kNm)	MZ (kNm)
1	+ve	0.000	0.000	0.000	0.000	0.000	0.000
1	+ve	-	-	-	-	-	-
1	-ve	-0.095	-0.190	-0.097	0.000	0.000	0.000
1	-ve	Load: 1	Load: 1	Load: 1	-	-	-
2	+ve	0.000	0.190	0.097	0.000	0.000	0.000
2	+ve	-	Load: 1	Load: 1	-	-	-
2	-ve	-0.095	0.000	0.000	0.000	0.000	0.000
2	-ve	Load: 1	-	-	-	-	-
5	+ve	0.000	0.000	0.097	0.000	0.000	0.000
5	+ve	-	-	Load: 1	-	-	-
5	-ve	-0.095	-0.190	0.000	0.000	0.000	0.000
5	-ve	Load: 1	Load: 1	-	-	-	-

6	+v	0.000	0.190	0.000	0.000	0.000	0.000
6	+v	-	Load: 1	-	-	-	-
6	-v	-0.095	0.000	-0.097	0.000	0.000	0.000
6	-v	Load: 1	-	Load: 1	-	-	-

Min FZ	1	1:LOAD CASE 1	0.000	0.000	**0.000**

Failure Ratio

There is no data of this type.

Failed Members

There is no data of this type.

Base Pressure

Node	L/C	FX (N/mm²)	FY (N/mm²)	FZ (N/mm²)
1	1:LOAD CASE 1	0.000	0.000	0.000
2	1:LOAD CASE 1	0.000	0.000	0.000
5	1:LOAD CASE 1	0.000	0.000	0.000
6	1:LOAD CASE 1	0.000	0.000	0.000

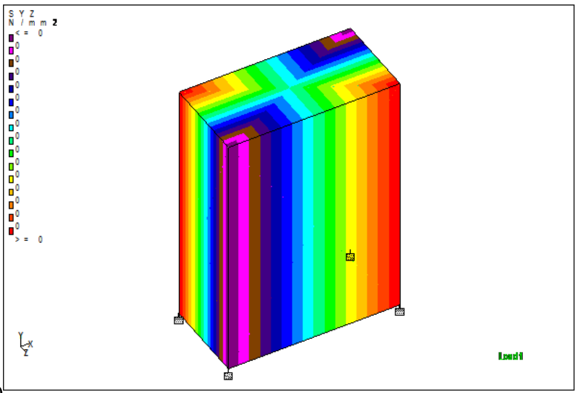

Figure 4.1 Stress Diagram

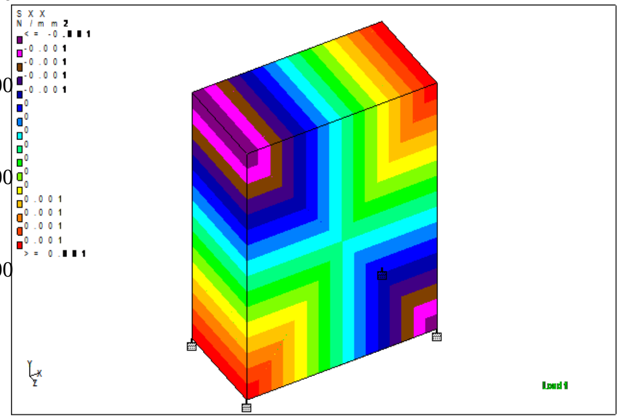

Figure 4.2 Longitudinal Stresses

Base Pressure Summary

	Node	L/C	FX (N/mm²)	FY (N/mm²)	FZ (N/mm²)
Max FX	1	1:LOAD CASE 1	**0.000**	0.000	0.000
Min FX	1	1:LOAD CASE 1	**0.000**	0.000	0.000
Max FY	1	1:LOAD CASE 1	0.000	**0.000**	0.000
Min FY	1	1:LOAD CASE 1	0.000	**0.000**	0.000
Max FZ	1	1:LOAD CASE 1	0.000	0.000	**0.000**

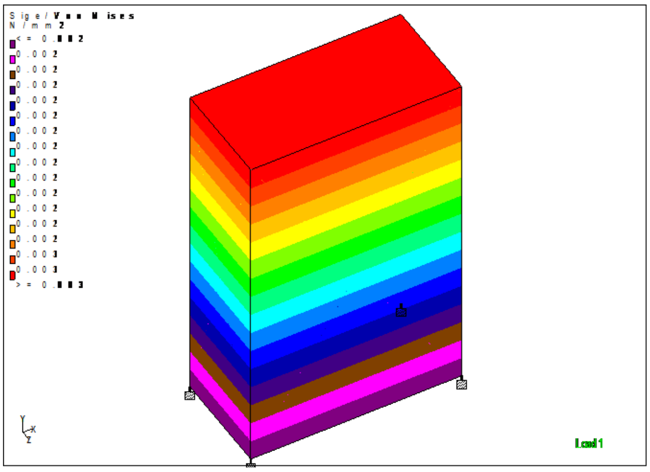

Figure 4.3 Vonmisses Stress

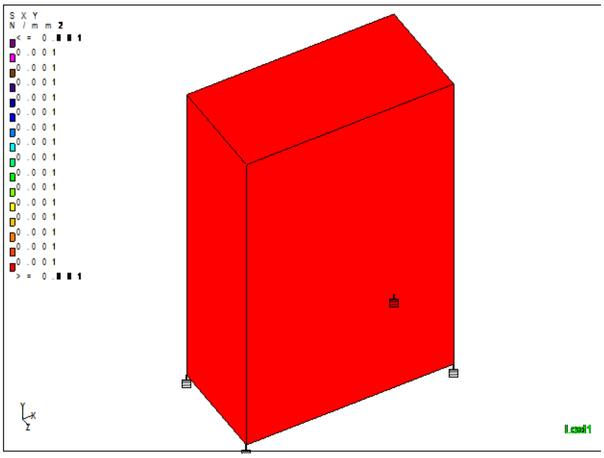

Figure 4.4 Stress in X-y Direction

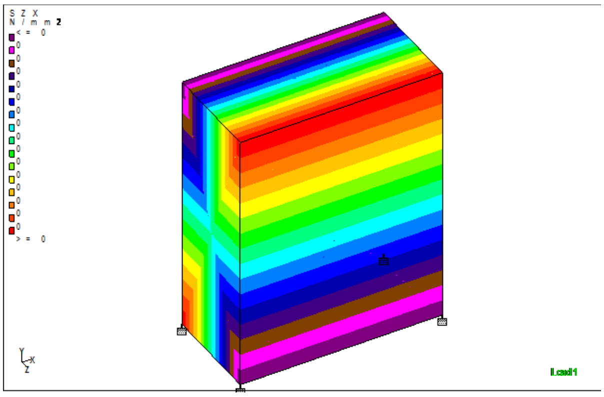

Figure 4.5 Stress in Z-x Direction

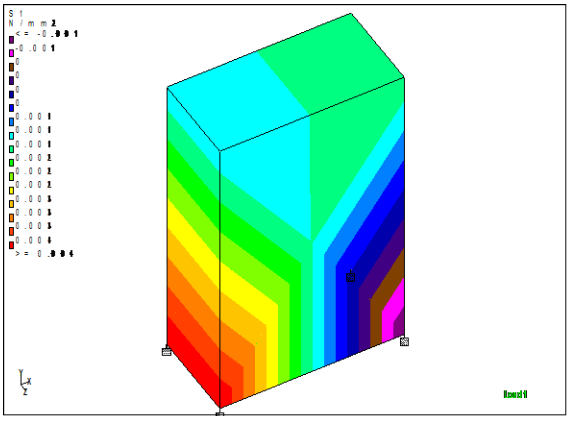

Figure 4.6 Corner Stress

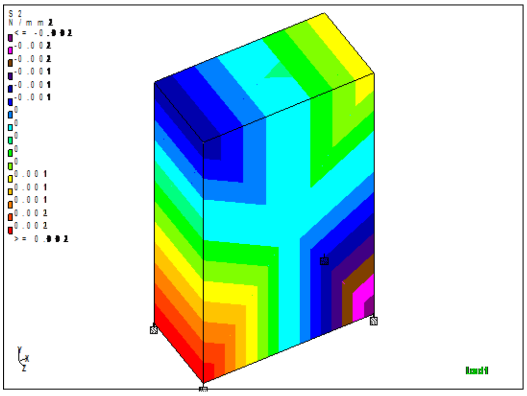

Figure 4.7 Corner Stress 2

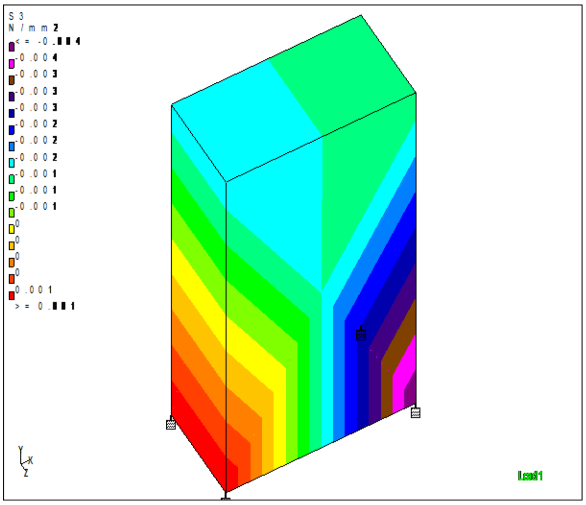

Figure 4.8 Corner Stress 3

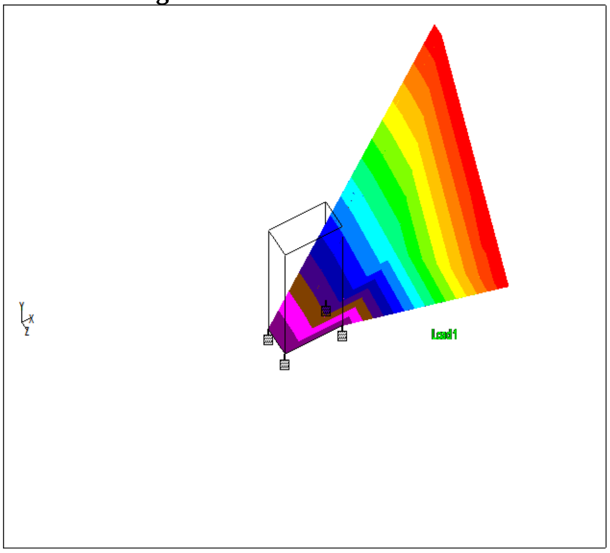

Figure 4.9 Displacement Due To Stress

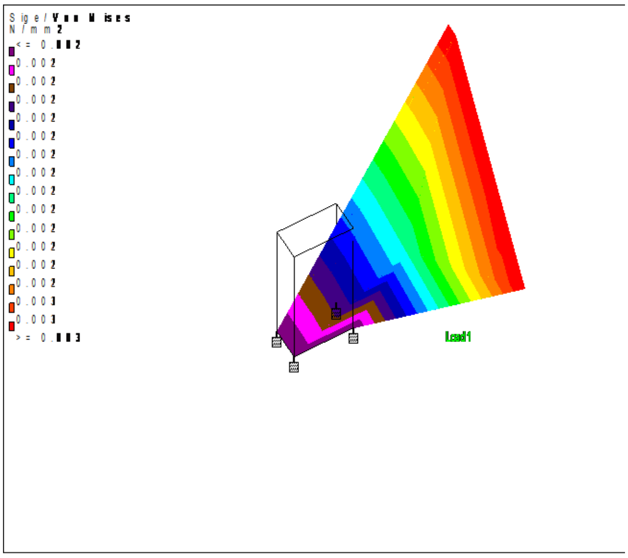

Figure 4.10 Displacement Due To Stress 2

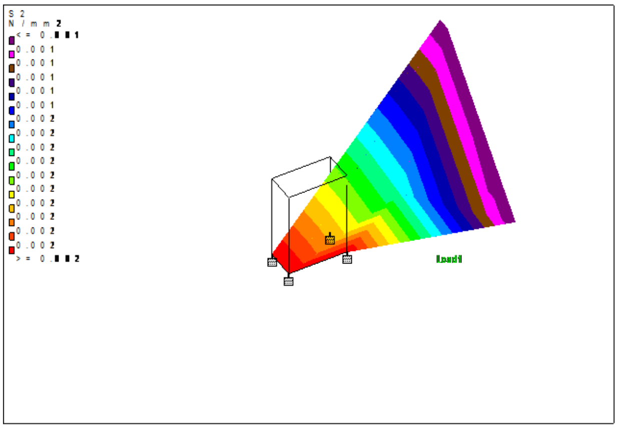

Figure 4.11 Displacement Due To Stress3

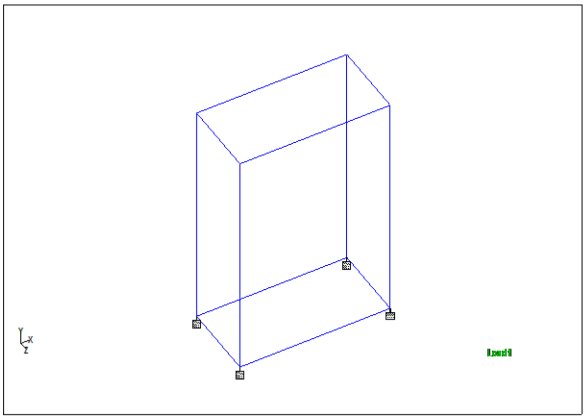

Figure 4.12 Whole Structures

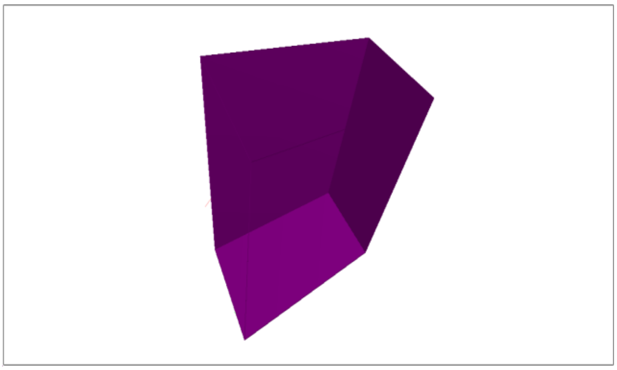

Figure 4.13 3d Rendered Views

VI CONCLUSIONS

Construction with unmortared block of rocks is venerable and universal even in seismically active regions. That so many historic and culturally valuable structures have survived is a testament to careful engineering craftsmanship. Finely fitted, massive blocks of rock and well-constructed interior cores and backfill assure the survival of these structures better than poorly constructed unreinforced masonry of modern communities nearby. Modes of failure of rock block structures under seismic loading observed in the STAAD output results in graphically .The major failure zone has be identify with red pattern which is highly stressed zone in that location seismic loading will be more and it indicate the failure of the block has took place. In our project with small sample of block has subject to dynamic load which indicates more stress points and their deformation in detail. Thus we conclude the result generate from our STAAD has vital role in construction field with rock blocks and their features.

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