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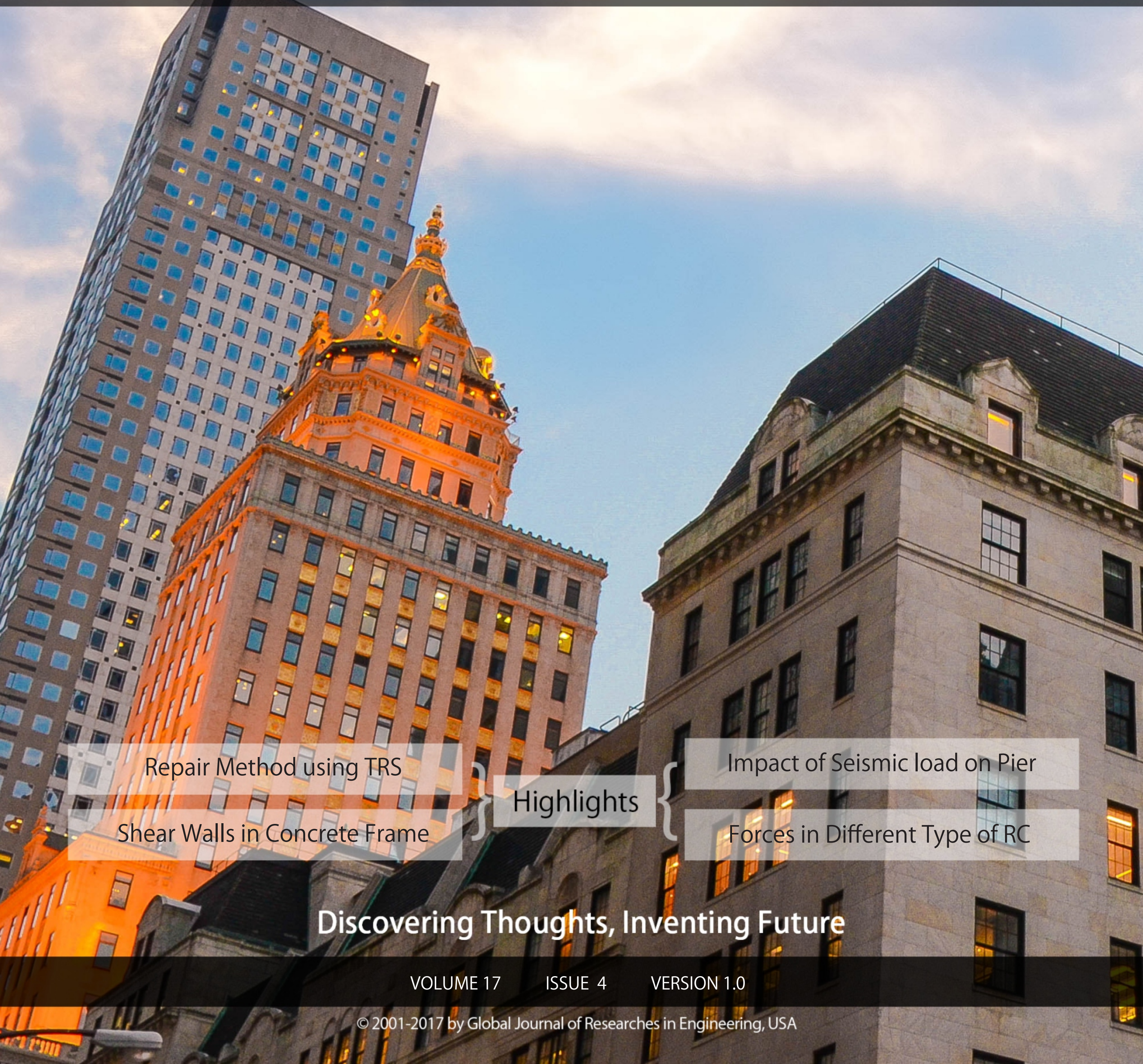

Highlights

- Repair Method using TRS
- Shear Walls in Concrete Frame
- Impact of Seismic load on Pier
- Forces in Different Type of RC

Discovering Thoughts, Inventing Future

VOLUME 17 ISSUE 4 VERSION 1.0

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A Study on Repair Method using TRS for Fatigue Cracks in Orthotropic Steel Deck

By Yoshiaki Mizokami, Masafumi Kamataa, Yuki Kishia & Masahiro Sakanob

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Abstract- For the purpose of reducing dead load, an orthotropic steel deck is used in many long span bridges. The Honshu-Shikoku Bridges use orthotropic steel decks stiffened by closed section ribs (trough rib) as well. With the increase of the service years, fatigue cracks resulting from large vehicles have been observed. For the bead-penetrating cracks that initiate at weld root and grow toward bead surface in troughdeck weld, several repair methods have been studied. However, effective methods that are applicable from the underside of the deck are still under development. In this paper, development of plate-splicing methods that are applicable from the underside of the deck using Thread Rolling Screw and other fasteners and results of the fatigue tests to confirm their performances are described.

Keywords: *orthotropic steel deck, fatigue crack, crack repair, thread rolling screw.*

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A Study on Repair Method using TRS for Fatigue Cracks in Orthotropic Steel Deck

Yoshiaki Mizokami [α], Masafumi Kamataa [σ], Yuki Kishia [ρ] & Masahiro Sakanob [ω]

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Keywords: orthotropic steel deck, fatigue crack, crack repair, thread rolling screw.

I. Introduction

The Honshu-Shikoku Bridges *(Fig.1)* that connect Honshu and Shikoku by three routes consist of 10 suspension bridges including the Akashi Kaikyo Bridge, the longest suspension bridge in the world, 5 cable-stayed bridges, one truss bridge and one arch bridge.

For these long-span bridges, dead load occupies large part of the cross-sectional force of the major members. In order to reduce the dead load, they use light-weight orthotropic steel decks (OSD). OSD consisting of deck plates, trough ribs, and cross ribs are supported by main girders in which the deck plates act as upper flange.

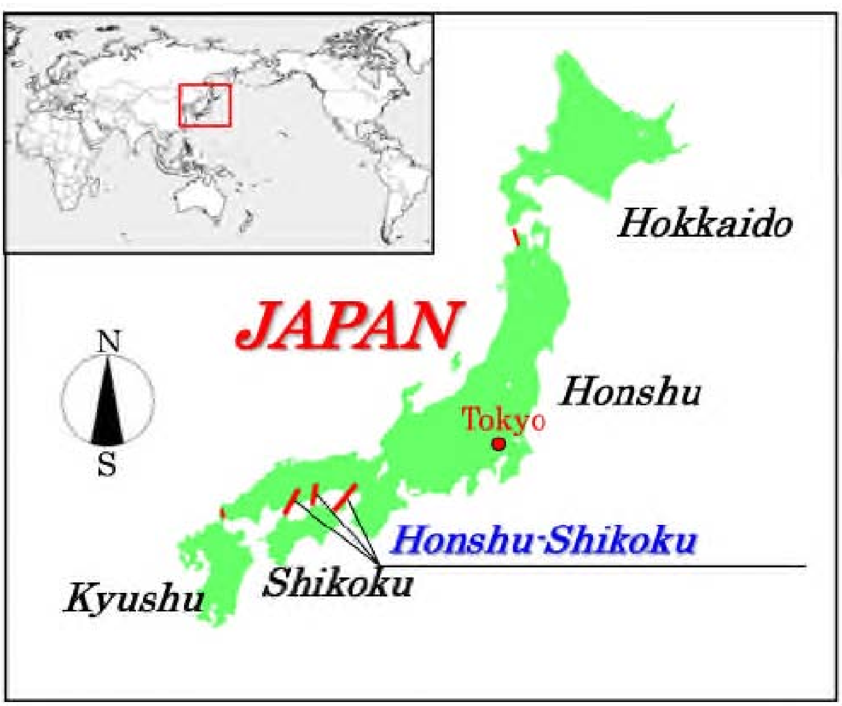

Fig. 1: Location of Honshu-Shikoku Bridges.

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Author ω: Kansai University, Dept. Civil, Environmental and Applied System Engineering, Japan. e-mail: peg03032@kansai-u.ac.jp.

II. Current Situation of Fatigue Cracks and Repair Methods

Several types of fatigue cracks are reported [1, 2]. For the OSD with closed-section trough ribs, many cases of cracks initiating from trough-deck welds toward the surface of the weld bead (hereinafter, "bead-penetrating crack") as shown in Fig. 2 are reported [1-4].

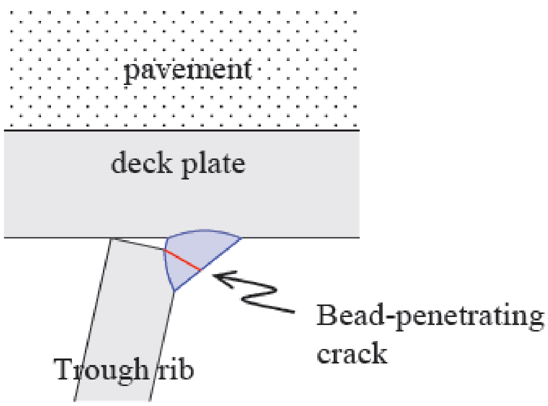


Fig. 2: Bead-penetrating crack.

The following existing repair methods have advantages and disadvantages. Replacement of trough ribs or plate-splicing require installation of high-tension bolts from the topside of the deck. Re-welding or plate-splicing with stud bolts are applicable from the underside.

Replacement of trough ribs or plate-splicing require traffic restriction for the removal of the pavement. Therefore, social impact is large for the heavy traffic highways or strait-crossing long span bridges that have no alternative routes. Also, pavement joint created by the partial pavement removal and repaving may degrade waterproofing performance.

For the re-welding from the underside, quality control is difficult because the method forces welders to weld in an upward direction. Also, if the traffic cannot be closed, traffic vibration is not avoidable during welding work and it may degrade welding quality. Because welding inside the trough rib is difficult and it is welded from the outside in general, full penetration welding cannot be done and unwelded parts tend to remain at root. That is, for the re-welding, quality may not be assured and anxiety for the reappearance of cracks from root remains.

For the plate splicing with stud bolts, quality control may be difficult because of upward welding. Also, because the studs are welded to the deck plate in which stress amplitude by the live load is large, fatigue cracks from weld toe toward the deck may be a concern.

Although several repair methods for bead-penetrating crack were proposed, there is no effective method that is applicable from the underside of the deck currently.

III. Developped Repair Method and Outline of Fatigue Test

The repair method proposed here is a plate splicing method that requires no traffic control and applicable from the underside of the deck. In this method, connection of the splicing plate and deck plate is bearing joint with bolts or screws instead of conventional friction joint with torque shear bolts. Bolt holes are perforated from the underside of the deck. Connection of splicing plate and trough rib is one side bolt for all type.

In order to confirm performance of the method, fatigue tests with actual size test model (Fig. 3) are conducted. As bearing joint, a method using tap bolt (TB) in that steel plate is perforated and tapped, and the bolt is screwed, and a method using Thread Rolling Screw (TRS) in that after perforated steel plate, the bolt is screwed forming female threads are selected [5-7]. Also, as a bench mark to evaluate these methods, friction joint with torque shear bolt (HTB) is tested as well. Fig. 4 shows details of each repair method.

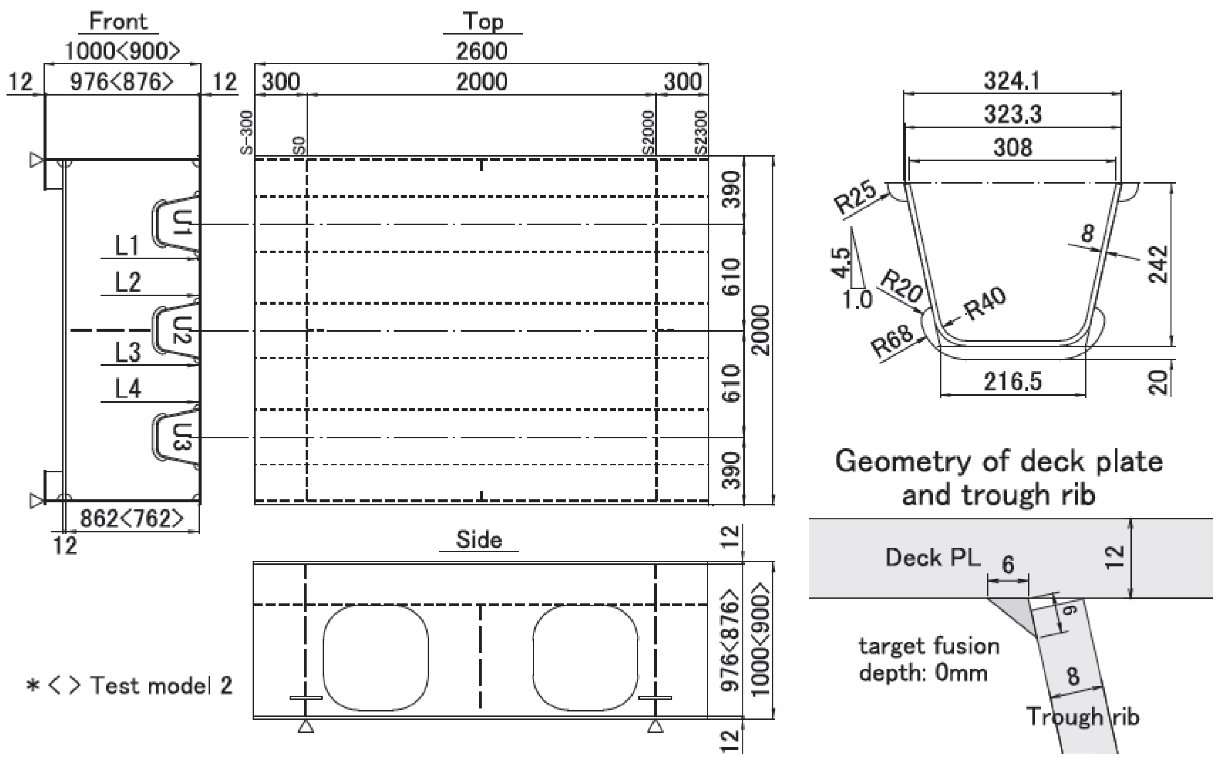


Fig. 3: Test model.

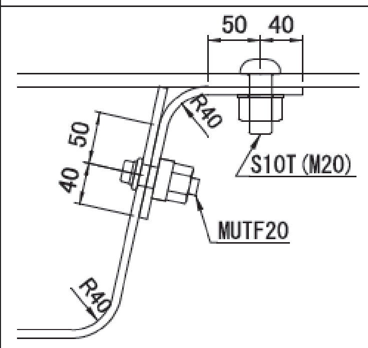
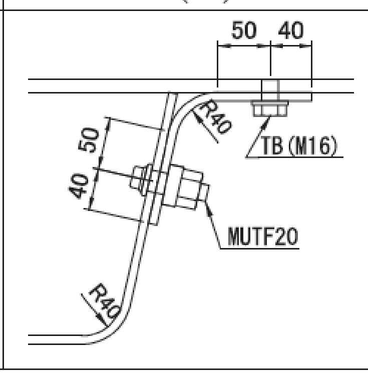
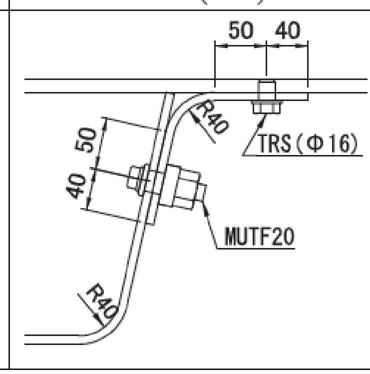
	L1(HTB)	L2(TB)	L3･L4(TRS)
Detail			

Fig. 4: Detail of plate splicing.

IV. Fatigue Test

a) *Test model and applied load*

The size of the test model is 2,000mm wide and 2,600mm long. Heights of the No.1 and No.2 are 1,000mm and 900mm, respectively. They have two cross ribs and three trough ribs (nominal dimension: 320x260x8-40) between two main girders. Spacing of trough ribs and cross ribs are 610mm and 2,000mm, respectively.

Thickness and materials of deck plate, trough rib and web of cross rib are 12mm (SM490Y), 8mm (SM490Y) and 9mm (SM400), respectively. Thickness and material of splicing plate are same as those of trough rib. The splicing plates are applied from L1 to L4 in Fig. 3. Longitudinally, they are applied between S-300 and S2000 and divided at 600mm and 1,400mm from cross rib.

Deck plate and trough rib are welded with target leg length of 6mm and fusion depth of 0mm.

Three types of connections of splicing plate and deck plate are shown in Fig. 4. L1 is a friction joint with HTB (M20), L2 is a bearing joint with TB (M16) and L3 and L4 are bearing joint with TRS (ϕ16). Connection of splicing plate and trough rib is one side bolt (MUTF20) for all types.

Applied load is 260kN/axle referring to [3]. With using loading beam, the load is distributed by 4 rubber seats (200x200mm, t=40mm) per axle mimicking double tires. The loading machine has three jacks and they are set at S0, S600 and S1200 or S800, S1400 and S2000. The load is applied dynamically with frequency of 3Hz. Phase difference of each jack is 2/3 π (120 degrees).

Two loading patterns are shown in Fig. 5. In the first loading case, load is applied directly above bead line of deck plate and trough rib. In the second loading case, load is applied so that the bead line is in between two adjacent loads.

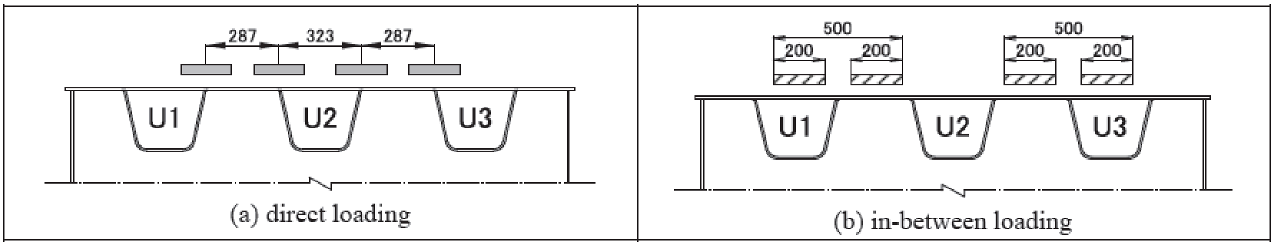


Fig. 5: Loading pattern.

b) *Test cases*

i. *Test model 1*

Corrective maintenance case and preventive maintenance case in which plate splicing is conducted after and before bead-penetrating crack is generated, respectively, are planned. For the preventive maintenance case, weld bead is left in one case (bead-left case). And in the other case, weld bead is cut in order to eliminate root where crack starts (bead-cut case).

Fusion depth of weld of deck plate and trough rib is confirmed to be 4mm instead of target value of 0mm. Since the generation of bead-penetrating crack is considered to be difficult with this fusion depth, this model is used for bead-cut case. And another model (test model 2) is made for bead-left case.

Range of the bead cut is the range of the loading rubber seat +10mm. Bead is cut carefully not to cut into deck plate with whetstone. Confirmation of fusion depth is shown in Photo. 1. Bead cut is shown in Fig. 6. Loading positions are directly above the bead lines of L1 - L4. Bead cut range and loading position is shown in Fig. 7.

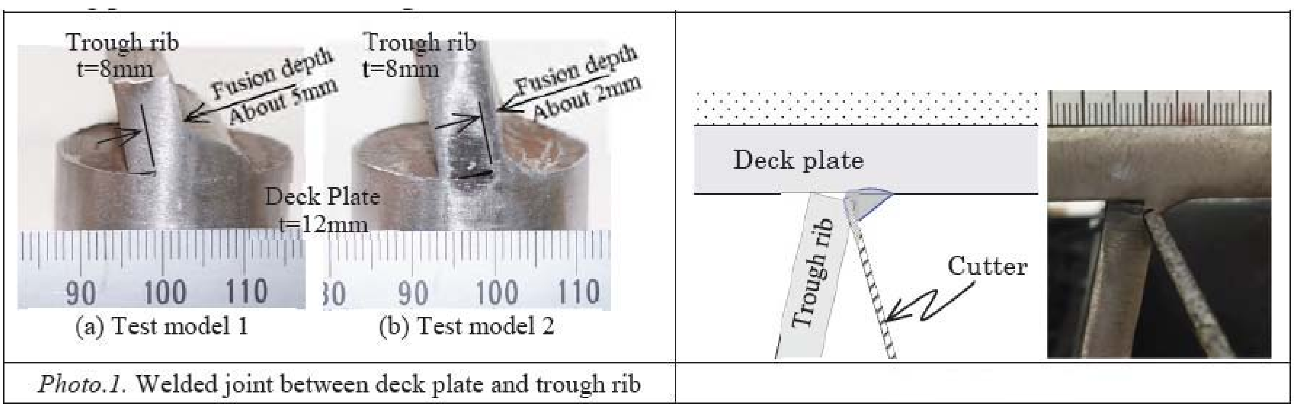


Fig. 6: Bead Cut.

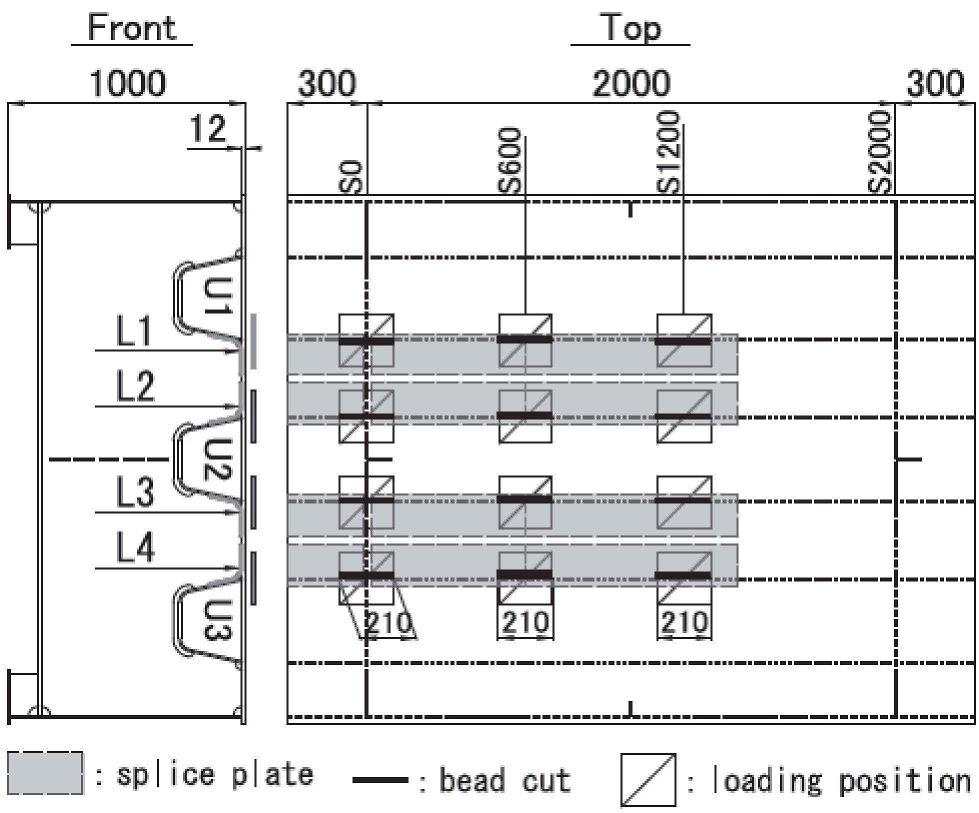


Fig. 7: Test model 1.

ii. *Test model 2*

Since the fusion depth of the test model 2 is less than 2mm (Photo 1(b)), corrective maintenance case and preventive maintenance case are tested. Flow of the test is shown in Fig. 8. Loading pattern and position is shown in Fig. 9.

In the corrective maintenance case, plate splicing is applied after bead-penetrating cracks are generated by the loading above cross rib (S0) and mid span (S600 and S1200). In the preventive maintenance case, load is applied above mid span (S800 and S1400) and cross rib (S2000) where plate splicing is applied without cracks. For L3, weld bead is cut before plate splicing.

In the corrective maintenance case, load is applied directly above weld lines of L1 - L4. In the preventive maintenance case, in-between loading above weld lines of L1 and L4 is conducted after direct loading.

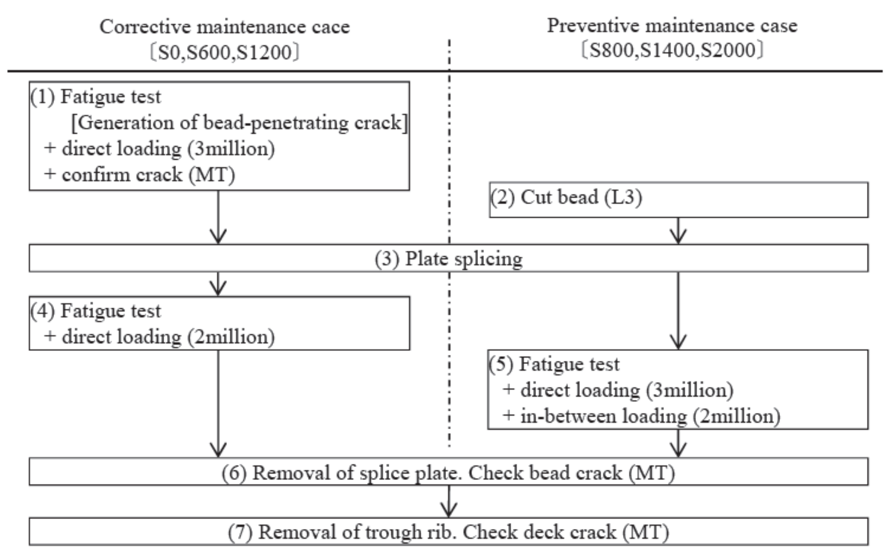


Fig. 8: Test flow of test model 2.

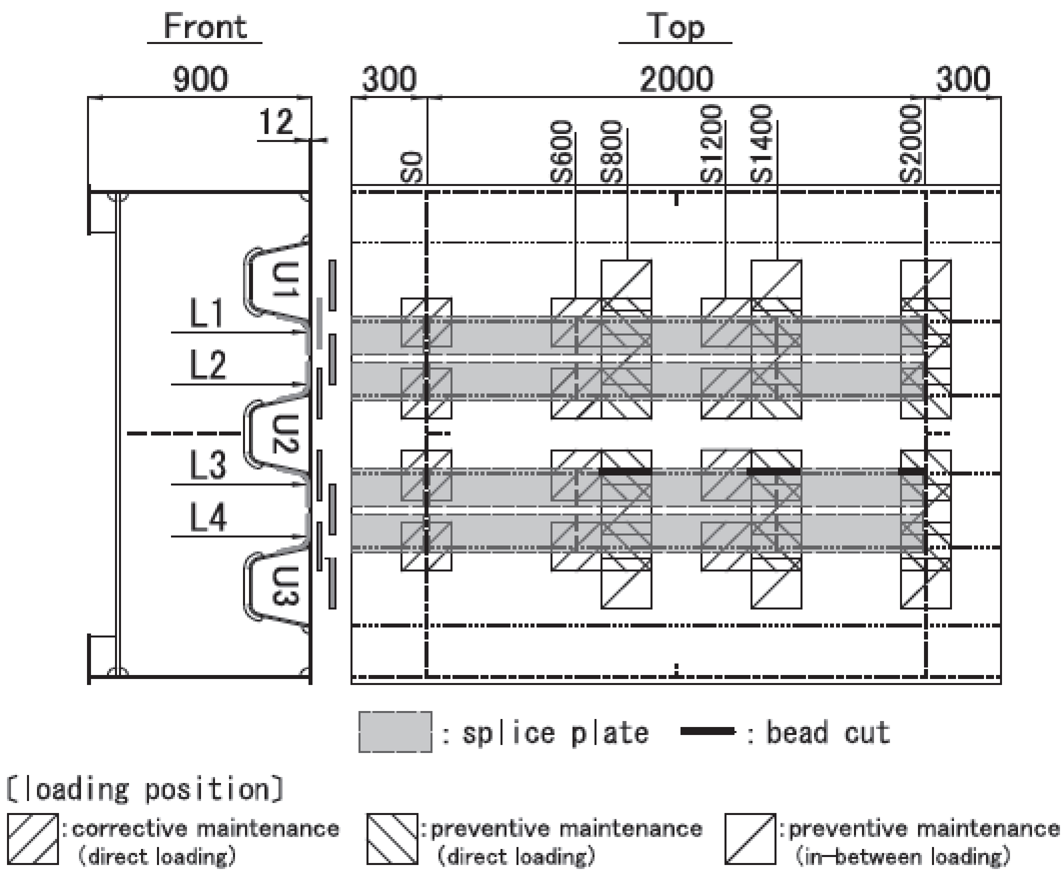


Fig. 9: Test model 2.

V. Test Result

a) Test model 1

After the direct loading of 3 million times, crack generation and loosening of the bolts are checked and adjacent area of bolt holes is surveyed.

No problems are found for HTB, TB and TRS. Splicing plates are removed and deck plate, trough ribs and bolt holes are surveyed by magnetic particle testing (MT) and no cracks are found. Further, deck plate and trough rib where load is applied is cut out by gas cutting and deck crack is surveyed by MT and no deck crack is found. It is confirmed that weld bead is completely cut by the progress of crack by the dynamic loading even if weld bead is partially uncut. No problems are found at the joint of splicing plates.

b) Test model 2 (Corrective maintenance case)

i. *Generation of bead-penetrating crack*

Distribution of cracks after direct loading of 3 million times (1 million times for S0 because crack is generated by 1 million times) is shown in Fig. 10. Bead cracks are checked by MT from the bead surface. Since deck cracks that do not appear on the surface cannot be surveyed without removal of trough ribs, they are surveyed by MT from the bottom side of the deck after all the loading cases and removal of trough ribs.

At S0 on L1, a bead-penetrating crack with surface crack length of 24mm is observed. At the other 11 loading locations, no bead-penetrating cracks are found and internal cracks with length of 1 to 6mm are found at the depth of 3 to 5mm by the removal of surface. At 7 locations out of 11, cracks with length of 6 to 60mm progressing toward deck are found. Progress of these cracks might suppress bead-penetrating cracks. At the other 4 locations, no deck cracks are found.

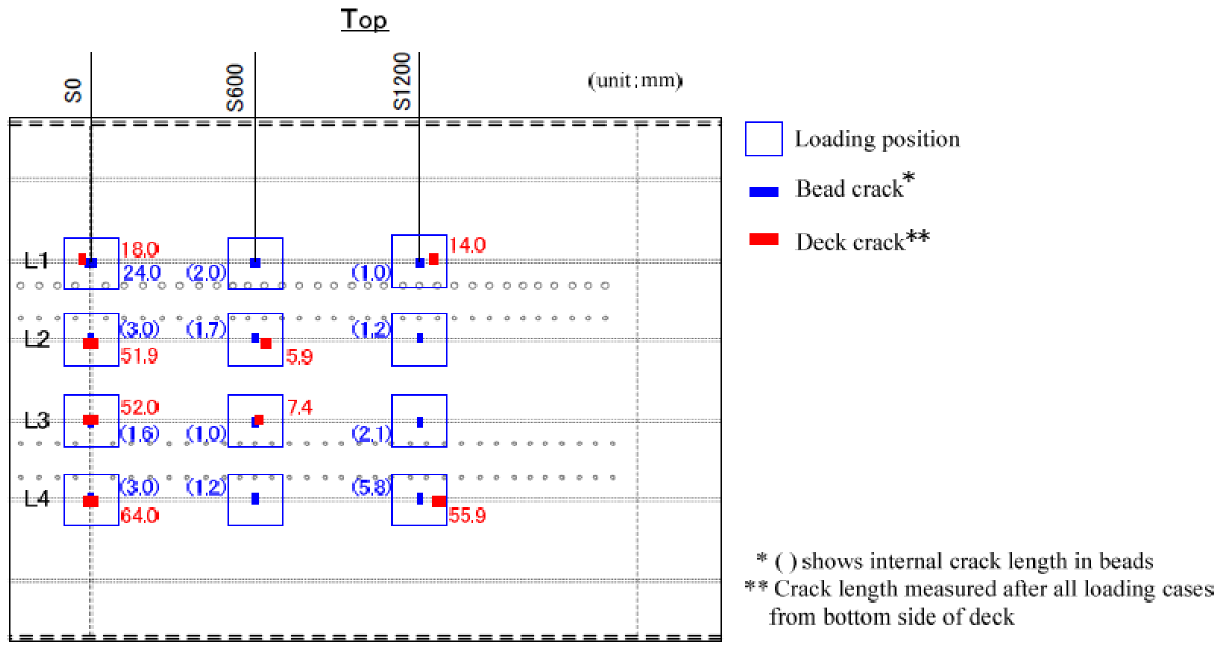


Fig. 10: Crack distribution (after generation of bead-penetrating crack).

ii. *Fatigue test*

After the generation of bead-penetrating and internal cracks, plate splicing is applied and direct loading of 2 million times is conducted. Distribution of cracks after loading is shown in Fig. 11. Bead cracks are checked by MT after loading. Deck cracks are checked after the removal of trough ribs by MT from the bottom side of deck plate.

Surface crack length at S0 on L1 grows from 24mm to 39mm. On L2 and L3, although bead cracks do not grow, deck cracks with length of over 50mm are observed.

At 4 locations out of 8 on S600 and S1200 where internal cracks are generated before plate splicing, bead-penetrating cracks with surface crack length of 120 -200mm are found. At one of them, deck crack initiates from the end of bead-penetrating crack. At the other 3 locations, although progress of internal cracks is not observed, deck cracks are found.

It is found that bead cracks or deck cracks may progress if plate splicing is applied without bead cut.

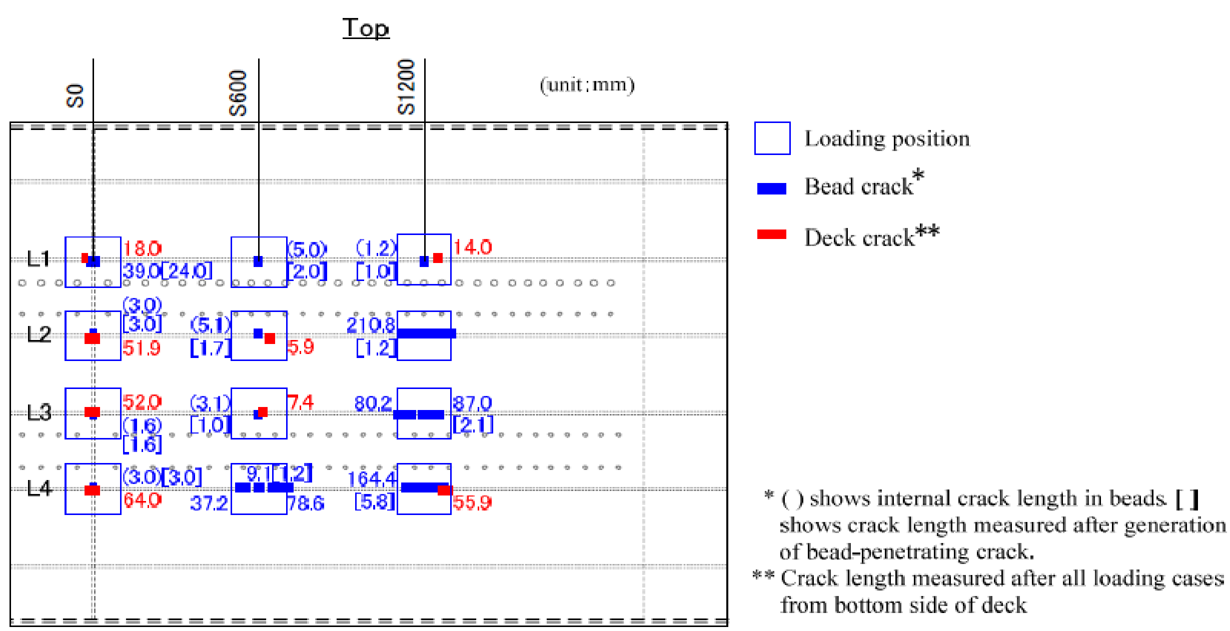


Fig. 11: Crack distribution (after fatigue test).

c) Test model 2 (Preventive maintenance case)

Distribution of cracks after direct loading of 3 million times with plate splicing before the loading is shown in Fig. 12. Bead cracks and deck cracks are observed by MT from bottom side of deck after all loading and removal of trough ribs.

On L3 where weld bead beneath loading positions are cut, no deck cracks are observed. On the other hand, bead crack and deck crack are found at the end of bead cut. From this, countermeasure is required at the end of splicing plate, like drilling holes [8] in order to suppress and monitor the reappearance of crack.

On L2 and L4, bead-penetrating cracks with surface crack length of 40 to 90mm are observed at all the locations. No deck cracks are found.

On L1, bead-penetrating cracks and deck cracks are observed at all the locations. Crack lengths of bead-penetrating cracks and deck cracks are 10 to 50mm and 30 to 70mm, respectively. Although the loading condition for L1 and L4 is the same, generation of cracks is different. Difference may be caused by difference of connection method (L1: HTB, L4: TRS) and fusion depth.

Plate splicing without bead cut causes bead cracks and deck cracks. On the other hand, no cracks are found where beads are cut although some are found at the end of bead cut. From these, bead is not required when plate splicing is applied and it is needed to be removed.

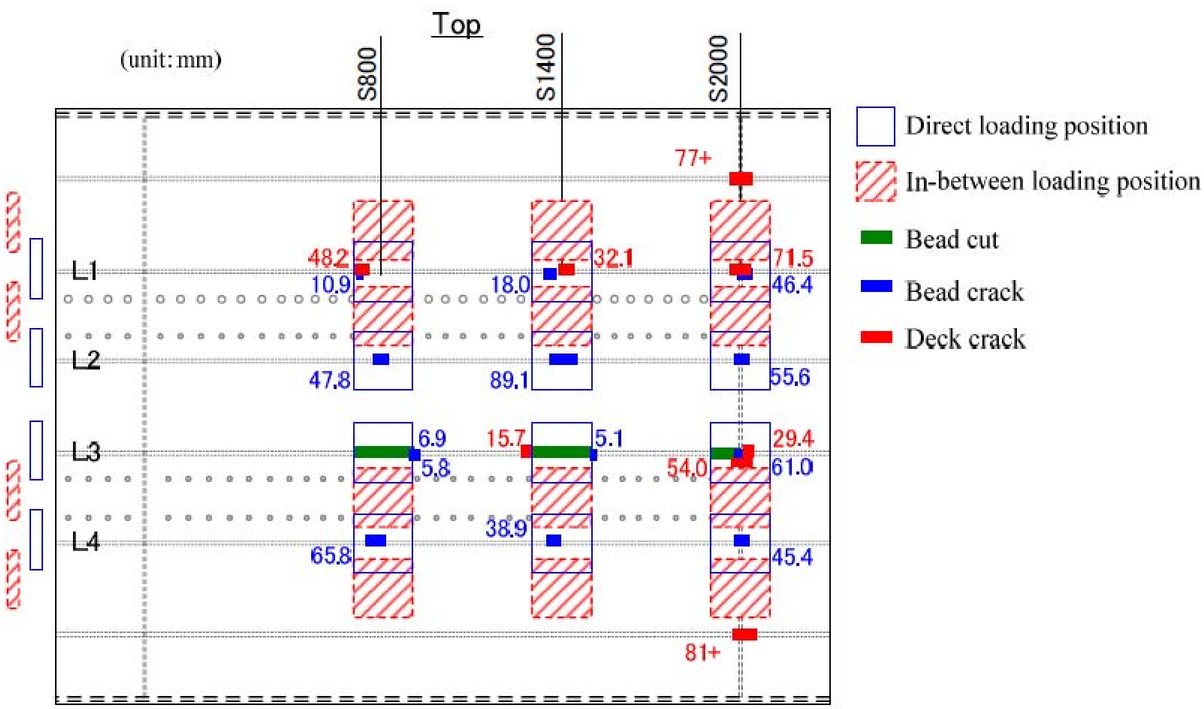


Fig. 12: Crack distribution (after all loading)

VI. Conclusion

a) Generation of bead cracks

A bead-penetration crack is generated at one of the intersections of cross rib (S0). Bead internal cracks are generated at the other 11 locations (three other locations on S0 and 8 on S600 and S1200). At 3 intersections and 4 mid-span locations out of the 11, deck cracks are generated. From these, both bead cracks and deck cracks tend to be generated at intersections.

b) Corrective maintenance case

From the fact that bead cracks and deck cracks appear and grow if plate splicing is applied without bead cut, it is confirmed to be necessary to cut bead.

c) Preventive Maintenance

It is found that deck cracks can be suppressed if plate splicing is applied with bead cut as preventive maintenance. Even if bead is not fully cut before plate splicing, remaining bead will be cut by repetitive loading and no deck cracks will be generated. No deck cracks are found where bead is cut. However, bead cracks or deck cracks may occur at the end of bead cut. From this, countermeasure is required at the end of bead cut in order to suppress and monitor the reappearance or progress of crack.

d) Evaluation of connection methods

For three connection methods (HTB, TB, and TRS), neither bolt loosening nor cracks from bolt holes are observed. Since there is no distinct difference between the methods both in corrective maintenance case and preventive maintenance case, they can be evaluated as equivalent within the range of the repetitive load and number of loading of the test.

From the view point of workability, TB and TRS can be applied from the underside. Especially for TRS, shaving process can be omitted compared with TB. TRS has higher workability and therefore has advantage over TB. In addition, good workability with TRS is confirmed at the execution tests at factory and actual bridge [9]. The soundness of TRS connection applied at the execution test in actual bridge will be confirmed by periodical investigation.

Acknowledgement

The authors would like to acknowledge the contribution of Takeshi Kusumoto, Daisuke Yamaoka, and Chihiro Sakamoto of Kansai University for the fatigue test.

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Impact of Seismic Load on Pier Forces in Different Type of RC Shear Walls in Concrete Frame Structures with Different Type of Soil Condition

By Mahdi Hosseini & N. V. Ramana Rao
Jawaharlal Nehru Technological University

Abstract- Shear walls are a type of structural system that provides lateral resistance to a building or structure. They resist in-plane loads that are applied along its height. The applied load is generally transferred to the wall by a diaphragm or collector or drag member. Shear walls are analyzed to resist two types of forces: shear forces and uplift forces. Shear forces are created throughout the height of the wall between the top and bottom shear wall connections. Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Shear walls are analyzed to the provide necessary lateral strength to resist horizontal forces.

Keywords: pier forces, response spectrum method, soft, medium & hard soil, time period, frequency and modal load participation ratios, C,Box,E,I and plus shapes RC shear wall, software ETABS.

GJRE-E Classification: FOR Code: 290899

IMPACTOFSEISMICLOADONPIERFORCESINDIFFERENTTYPEOFRCSHEARWALLSINCONCRETEFRAMESTRUCTURESWITHDIFFERENTTYPEOFSOILCONDITION

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Impact of Seismic Load on Pier Forces in Different Type of RC Shear Walls in Concrete Frame Structures with Different Type of Soil Condition

Mahdi Hosseini [α] & N. V. Ramana Rao [σ]

Abstract- Shear walls are a type of structural system that provides lateral resistance to a building or structure. They resist in-plane loads that are applied along its height. The applied load is generally transferred to the wall by a diaphragm or collector or drag member. Shear walls are analyzed to resist two types of forces: shear forces and uplift forces. Shear forces are created throughout the height of the wall between the top and bottom shear wall connections. Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Shear walls are analyzed to the provide necessary lateral strength to resist horizontal forces. Shear walls are strong enough, to transfer these horizontal forces to the next element in the load path below them. The seismic motion that reaches a structure on the surface of the earth is influenced by local soil conditions. The subsurface soil layers underlying the building foundation may amplify the response of the building to earthquake motions originating in the bedrock. Three types soil are considered here: Hard soil, Medium soil, soft soil. In the present work thirty story building with C Shape, Box shape, E Shape, I shape and Plus shape RC Shear wall at the center in Concrete Frame Structure with fixed support conditions under different type of soil for earthquake zone V as per IS 1893 (part 1): 2002 in India are analyzed using software ETABS by Dynamic analysis. All the analyses has been carried out as per the Indian Standard code books. This paper aims to Study the effect of Seismic load on Pier Forces in Different Type of RC Shear Walls in Concrete Frame Structures under Different Type of Soil Condition. Estimation of Pier Forces such as; Pier Axial Force , Pier moment, Pier shear Force, Pier Torsion, Time period and frequency and Modal Load Participation Ratios is carried out. In dynamic analysis; Response Spectrum method is used.

Keywords: pier forces, response spectrum method, soft, medium & hard soil, time period , frequency and modal load participation ratios, C,Box,E,I and plus shapes RC shear wall, software ETABS.

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I. Introduction

a) Shear wall structure

The usefulness of shear walls in framing of buildings has long been recognized. Walls situated in advantageous positions in a building can form an efficient lateral-force-resisting system, simultaneously fulfilling other functional requirements. When a permanent and similar subdivision of floor areas in all stories is required as in the case of hotels or apartment buildings, numerous shear walls can be utilized not only for lateral force resistance but also to carry gravity loads. In such case, the floor by floor repetitive planning allows the walls to be vertically continuous which may serve simultaneously as excellent acoustic and fire insulators between the apartments. Shear walls may be planar but are often of L-, T-, I-, or E, C, Box shaped section to better suit the planning and to increase their flexural stiffness.

The positions of shear walls within a building are usually dictated by functional requirements. These may or may not suit structural planning. The purpose of a building and consequent allocation of floor space may dictate required arrangements of walls that can often be readily utilized for lateral force resistance. Building sites, architectural interests or client's desire may lead the positions of walls that are undesirable from a structural point of view. However, structural designers are often in the position to advice as to the most desirable locations for shear walls in order to optimize seismic resistance. The major structural considerations for individual shear walls will be aspects of symmetry in stiffness, torsional stability and available overturning capacity of the foundations (Paulay and Priestley, 1992).

b) Earthquake Load

The seismic weight of building is the sum of seismic weight of all the floors. The seismic weight of each floor is its full dead load plus appropriate amount of imposed load, the latter being that part of the imposed loads that may reasonably be expected to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and movable partitions, permanent equipment, a part of the live load, etc. While computing the seismic weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. Earthquake forces experienced by a building result from ground motions (accelerations) which are also fluctuating or dynamic in nature, in fact they reverse direction somewhat chaotically. The magnitude of an earthquake force depends on the magnitude of an earthquake, distance from the earthquake source(epicenter), local ground conditions that may amplify ground shaking (or dampen it), the weight(or mass) of the structure, and the type of structural system and its ability to with stand abusive cyclic loading. In theory and practice, the lateral force that a building experiences from an earthquake increases in direct proportion with the acceleration of ground motion at the building site and the mass of the building (i.e., a doubling in ground motion acceleration or building mass will double the load).This theory rests on the simplicity and validity of Newton's law of physics: F = m x a, where 'F' represents force, 'm' represents mass or weight, and 'a' represents acceleration. For example, as a car accelerates forward, a force is imparted to the driver through the seat to push him forward with the car(this force is equivalent to the weight of the driver multiplied by the acceleration or rate of change in speed of the car). As the brake is applied, the car is decelerated and a force is imparted to the driver by the seat-belt to push him back toward the seat. Similarly, as the ground accelerates back and forth during an earthquake it imparts back-and-forth(cyclic) forces to a building through its foundation which is forced to move with the ground. One can imagine a very light structure such as fabric tent that will be undamaged in almost any earthquake but it will not survive high wind. The reason is the low mass (weight) of the tent. Therefore, residential buildings generally perform reasonably well in earthquakes but are more vulnerable in high-wind load prone areas. Regardless, the proper amount of bracing is required in both cases.

c) Importance of Seismic Design Codes

Ground vibration during earthquake cause forces and deformations in structures. Structures need to be designed withstand such forces and deformations. Seismic codes help to improve the behavior of structures so that may withstand the earthquake effect without significant loss of life and property. Countries around the world have procedures outlined in seismic code to help design engineers in the planning, designing, detailing and constructing of structures.

i. *An earthquake resistant has four virtues in it, namely*

a. *Good Structural Configuration*

Its size, shape and structural system carrying loads are such that they ensure a direct and smooth flow of inertia forces to the ground.

b. *Lateral Strength*

The maximum lateral (horizontal) force that it can resist is such that the damage induced in it does not result in collapse.

c. *Adequate Stiffness*

Its lateral load resisting system is such that the earthquake – indeed deformations in it do not damage its contents under low-to- moderate shaking.

d. *Good Ductility*

Its capacity to undergo large deformations under severe earthquake shaking even after yielding is improved by favorable design and detailing strategies.

ii. *Indian Seismic Codes*

Seismic codes are unique to a particular region or country. They take into account the local seismology, accepted level of seismic risk, buildings typologies, and materials and methods used in construction.

The Bureau of Indian Standards (BIS) the following Seismic Codes:

IS 1893 (PART 1) 2002, *Indian Standard Criteria* for Earthquakes Resistant of Design Structures (5th revision).

IS 4326, 1993, Indian Standard Code of practice for Earthquake Resistant Design and Construction of Buildings. (2nd revision).

IS 13827, 1993, Indian Standard Guidelines for improving Earthquake Resistant of Earthen buildings.

IS 13828, 1993 Indian Standard Guidelines for improving Earthquake Resistant of Low Strength Masonry Buildings.

IS 13920, 1993, Indian Standard Code for practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

The regulations in these standards do not ensure that structures suffer no damage during earthquake of all magnitude. But, to the extent possible, they ensure that structures are able to respond to earthquake shaking of moderate intensities without structural damage and of heavy intensities wit out total collapse.

d) Site Selection

The seismic motion that reaches a structure on the surface of the earth is influenced by local soil conditions. The subsurface soil layers underlying the building foundation may amplify the response of the building to earthquake motions originating in the bedrock.

For soft soils the earthquake vibrations can be significantly amplified and hence the shaking of structures sited on soft soils can be much greater than for structures sited on hard soils. Hence the appropriate soil investigation should be carried out to establish the allowable bearing capacity and nature of soil. The choice of a site for a building from the failure prevention point of view is mainly concerned with the stability of the ground. The very loose sands or sensitive clays are liable to be destroyed by the earthquake, so much as to lose their original structure and thereby undergo compaction. This would result in large unequal settlements and damage the building. If the loose cohesion less soils are saturated with water they are likely to lose their shear resistance altogether during ground shaking. This leads to liquefaction. Although such soils can be compacted, for small buildings the operation may be too costly and the sites having these soils are better avoided.

For large building complexes, such as housing developments, new colonies, etc. this factor should be thoroughly investigated and the site has to be selected appropriately. Therefore a site with sufficient bearing capacity and free from the above defects should be chosen and its drainage condition improved so that no water accumulates and saturates the ground especially close to the footing level.

e) Bearing capacity of foundation soil

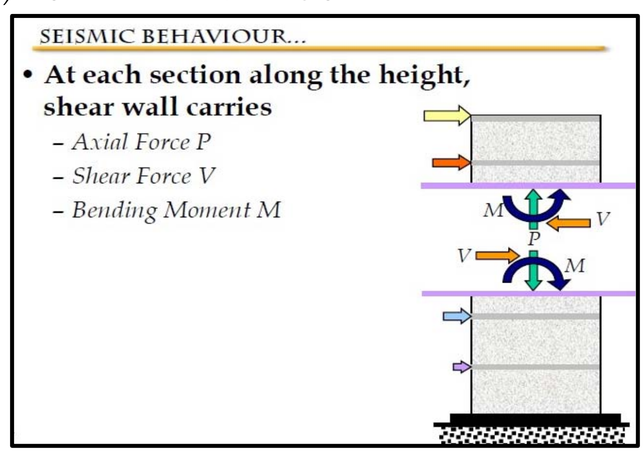
Three soil types are considered here:

i. *Hard*- Those soils, which have an allowable bearing capacity of more than 10t/m2.
ii. *Medium*- Those soils, which have an allowable bearing capacity less than or equal to 10t/m2.
iii. *Soft*- Those soils, which are liable to large differential settlement or liquefaction during an earthquake.

Soils must be avoided or compacted to improve them so as to qualify them either as firm or stiff. The allowable bearing pressure shall be determined in accordance with IS: 1888-1982 load test (Revision 1992). It is a common practice to increase the allowable bearing pressure by one-third, i.e. 33%, while performing seismic analysis of the materials like massive crystalline bedrock sedimentary rock, dense to very dense soil and heavily over consolidated cohesive soils, such as a stiff to hard clays. For the structure to react to the motion, it needs to overcome its own inertia, which results in an interaction between the structure and the soil. The extent to which the structural response may alter the characteristics of earthquake motions observed at the foundation level depends on the relative mass and stiffness properties of the soil and the structure.

Thus the physical property of the foundation medium is an important factor in the earthquake response of structures supported on it. There are two aspects of building foundation interaction during earthquakes, which are of primary importance to earthquake engineering. First, the response to earthquake motion of a structure founded on a deformable soil can be significantly different from that would occur if the structure is supported on a rigid foundation. Second, the motion recorded at the base of a structure or in the immediate vicinity can be different from that which would have been recorded had there been no building. Observations of the response of the buildings during earthquakes have shown that the response of typical structures can be markedly influenced by the soil properties if the soils are sufficiently soft. Furthermore, for relatively rigid structures such as nuclear reactor containment structures, interaction effects can be important, even for relatively firm soils because the important parameter apparently is not the stiffness of the soil, but the relative stiffness of the building and its foundation. In terms of the dynamic properties of the building foundation system, past studies have shown that the interaction will, in general, reduce the fundamental frequency of the system from that of the structure on a rigid base, dissipate part of the vibrational energy of the building by wave radiation into the foundation medium and modify the base motion of the structure in comparison to the free- field motion. Although all these effects may be present in some degree for every structure, the important point is to establish under what conditions the effects are of practical significance.

f) Seismic Behavior of RC Shear Wall



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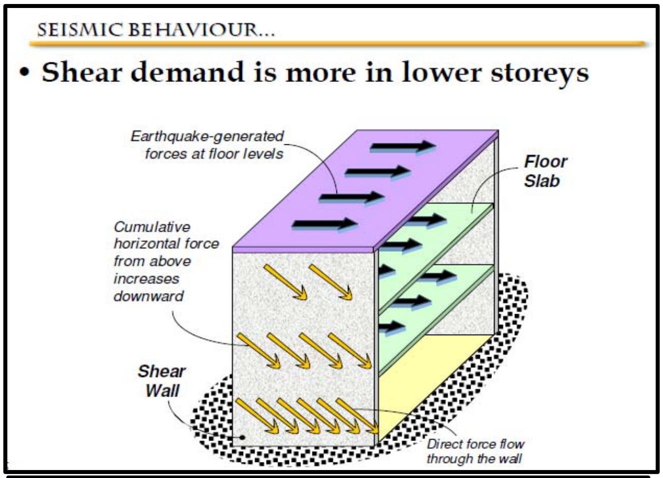

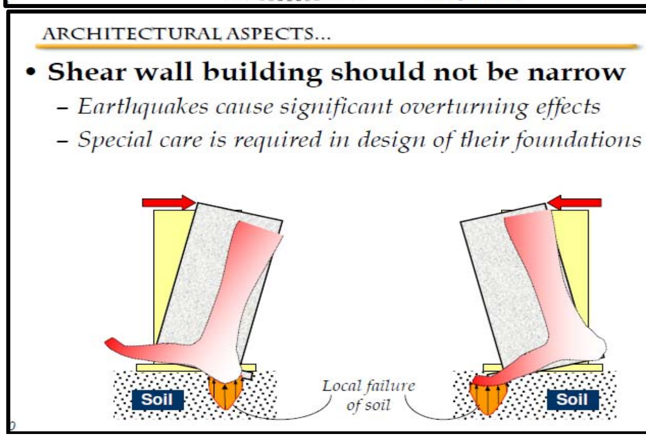

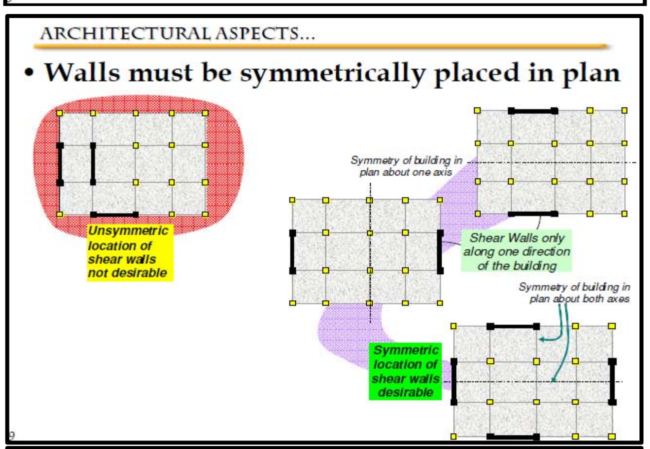

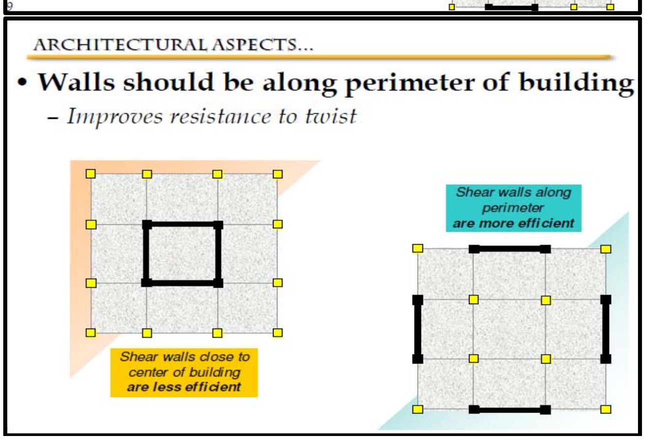

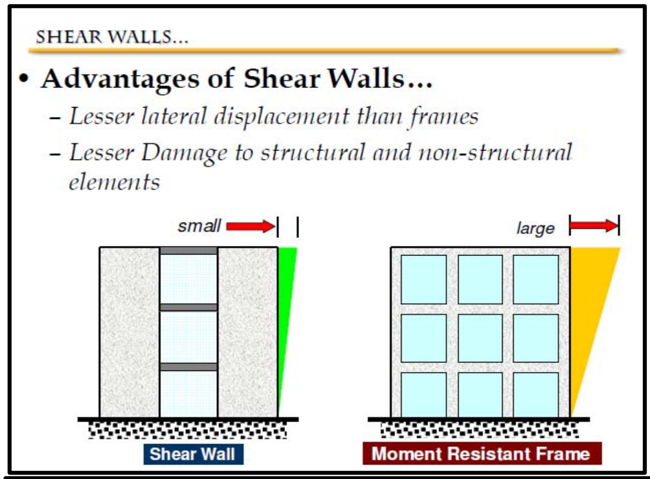

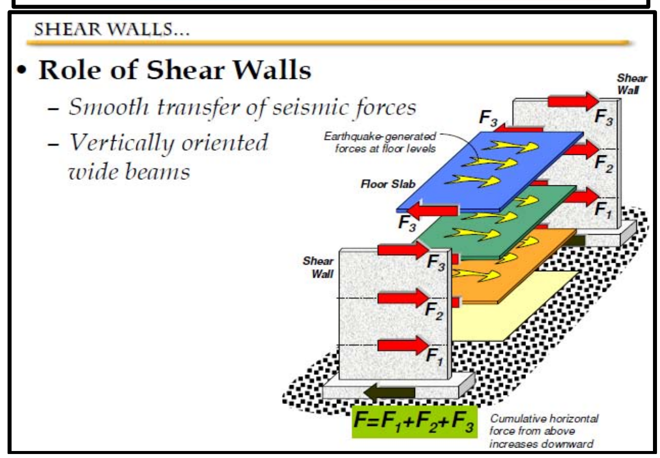

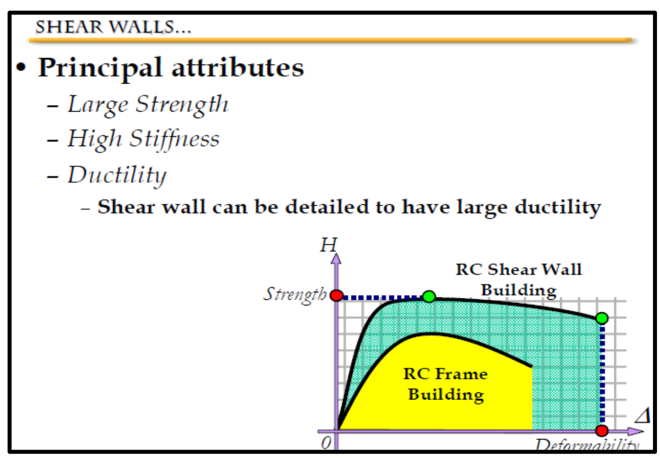

II. Methodology

Earthquake motion causes vibration of the structure leading to inertia forces. Thus a structure must be able to safely transmit the horizontal and the vertical inertia forces generated in the super structure through the foundation to the ground. Hence, for most of the ordinary structures, earthquake-resistant design requires ensuring that the structure has adequate lateral load carrying capacity. Seismic codes will guide a designer to safely design the structure for its intended purpose.

Quite a few methods are available for the earthquake analysis of buildings; two of them are presented here:

1. Equivalent Static Lateral Force Method (pseudo static method).
2. Dynamic Analysis.
   i. Response spectrum method.
   ii. Time history method.

a) Equivalent lateral Force (Seismic Coefficient) Method

This method of finding lateral forces is also known as the static method or the equivalent static method or the seismic coefficient method. The static method is the simplest one and it requires less computational effort and is based on formulae given in the code of practice.

In all the methods of analyzing a multi storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which include the weight of columns and walls in any storey should be equally distributed to the floors above and below the storey. In addition, the appropriate amount of imposed load at this floor is also lumped with it. It is also assumed that the structure flexible and will deflect with respect to the position of foundation the lumped mass system reduces to the solution of a system of second order differential equations. These equations are formed by distribution, of mass and stiffness in a structure, together with its damping characteristics of the ground motion.

b) Dynamic Analysis

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution in different levels along the height of the building, and in the various lateral load resisting element, for the following buildings:

Regular buildings: Those greater than 40m in height in zones IV and V, those greater than 90m in height in zone II and III.

Irregular buildings: All framed buildings higher than 12m in zones IV and V, and those greater than 40m in height in zones II and III.

The analysis of model for dynamic analysis of buildings with unusual configuration should be such that it adequately models the types of irregularities present in the building configuration. Buildings with plan irregularities, as defined in Table 4 of IS code: 1893-2002 cannot be modeled for dynamic analysis.

Dynamic analysis may be performed either by the TIME HISTORY METHOD or by the RESPONSE SPECTRUM METHOD

c) Time History Method

The usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics. In this method, the mathematical model of the building is subjected to accelerations from earthquake records that represent the expected earthquake at the base of the structure.

d) Response Spectrum Method

The word spectrum in engineering conveys the idea that the response of buildings having a broad range of periods is summarized in a single graph. This method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site. The values of damping for building may be taken as 2 and 5 percent of the critical, for the purposes of dynamic of steel and reinforce concrete buildings, respectively. For most buildings, inelastic response can be expected to occur during a major earthquake, implying that an inelastic analysis is more proper for design. However, in spite of the availability of nonlinear inelastic programs, they are not used in typical design practice because:

1. Their proper use requires knowledge of their inner workings and theories. design criteria, and
2. Result produced are difficult to interpret and apply to traditional design criteria , and
3. The necessary computations are expensive.

Therefore, analysis in practice typically use linear elastic procedures based on the response spectrum method. The response spectrum analysis is the preferred method because it is easier to use.

III. Literature Review

Generally, the building configuration which is conceived by architects and then accepted by developer or owner may provide a narrow range of options for lateral-load resistant systems that can be utilized by structural engineers. By observing the following fundamental principles relevant to seismic responses, more suitable structural systems may be adopted (Paulay and Priestley, 1992):

1. To perform well in an earthquake, a building should possess simple and regular configurations. Buildings with articulated plans such as T and L shapes should be avoided.
2. Symmetry in plans should be provided, wherever possible. Lack of symmetry in plan may lead to significant torsional response, the reliable prediction of which is often difficult.
3. An integrated foundation system should tie together all vertical structural elements in both principal directions. Foundation resting on different soil condition should preferably be avoided.
4. Lateral force resisting systems with significantly different stiffness such as shear walls and frames within one building should be arranged in such a way that at every level of the building, symmetry in lateral stiffness is not grossly violated. Thus, undesirable torsional effects will be minimized.

5. Regularity in elevation should prevail in both the geometry and the variation of story stiffness.

Prajapati R.J. et al., (2013) carried out study on deflection in high rise buildings for different position of shear walls. It was observed that deflection for building with shear walls provided at the corners in both the directions was drastically less when compared with other models.

Chandurkar P.P. et al., (2013) conducted a study on seismic analysis of RCC building with and without shear walls. They have selected a ten storied building located in zone II, zone III, zone IV and zone V. Parameters like Lateral displacement, story drift and total cost required for ground floor were calculated in both the cases.

Bhat S.M. et al., (2013) carried out study on Eathquakebehaviour of buildings with and without shear walls. Parameters like Lateral displacement, story drift etc were found and compared with the bare frame model.

Sardar S.J. et al., (2013) studied lateral displacement and inter-story drift on a square symmetric structure with walls at the centre and at the edges, and found that the presence of shear wall can affect the seismic behaviour of frame structure to large extent, and the shear wall increases the strength and stiffness of the structure.

Sagar K.et al., (2012) carried out linear dynamic analysis on two sixteen storey high buildings. It was concluded that shear walls are one of the most effective building elements in resisting lateral forces during earthquake. Providing shear walls in proper position minimizes effect and damages due to earthquake and winds.

Kumbhare P.S. et al., (2012) carried out a study on shear wall frame interaction systems and member forces. It was found that shear wall frame interaction systems are very effective in resisting lateral forces induced by earthquake. Placing shear wall away from center of gravity resulted in increase in the most of the members forces. It follows that shear walls should be coinciding with the centroid of the building.

Rahman A. et al., (2012) studied on drift analysis due to earthquake load on tall structures. In this study regular shaped structures have been considered. Estimation of drift was carried out for rigid frame structure, coupled shear wall structure and wall frame structure.

Anshuman et al., (2011) conducted a research on solution of shear wall location in multi storey building. An earthquake load was calculated and applied to a fifteen storied building located in zone IV. It was observed that the top deflection was reduced and reached within the permissible deflection after providing the shear wall.

Kameshwari B. et al., (2011) analyzed the effect of various configurations of shear walls on high-rise structure. The drift and inter-storey drift of the structure in the following configurations of shear wall panels was studied and was compared with that of bare frame. Diagonal shear wall configuration was found to be effective for structures in the earthquake prone areas.

Based on the literature review, the salient objective of the present study have been identified as follows:

- Behaviour of high rise structure with dual system with Different Type of RC Shear Walls (C, E,I, Box and Plus shapes) with seismic loading.
- To examine the effect of different types of soil (Hard, medium and Soft) on the overall interactive behaviour of the shear wall foundation soil system.
- The variation of maximum Pier Axial Force, Pier moment, Pier shear Force and Pier Torsion of the models has been studied.
- The variation of Time period and frequency has been studied.
- The variation of Modal Load Participation Ratios has been studied.

IV. Modeling of Building

a) Details of The Building

A symmetrical building of plan 38.5m X 35.5m located with location in zone V, India is considered. Four bays of length 7.5m& one bays of length 8.5m along X -direction and Four bays of length 7.5m& one bays of length 5.5m along Y - direction are provided. Shear Wall is provided at the center core of building model.

Structure 1: In this model building with 30 storey is modeled as a (Dual frame system with shear wall (Plus Shape) at the center of building, The shear wall acts as vertical cantilever.

Structure 2: In this model building with 30 storey is modeled as (Dual frame system with shear wall (Box Shape) at the center of building ,The shear wall acts as vertical cantilever.

Structure 3: In this model building with 30 storey is modeled as (Dual frame system with shear wall (C- Shape) at the center of building, The shear wall acts as vertical cantilever.

Structure 4: In this model building with 30 storey is modeled as (Dual frame system with shear wall (E- Shape) at the center of building ,The shear wall acts as vertical cantilever.

Structure 5: In this model building with 30 storey is modeled as (Dual frame system with shear wall (I-Shape) at the center of building, The shear wall acts as vertical cantilever.

b) Load Combinations

As per IS 1893 (Part 1): 2002 Clause no. 6.3.1.2, the following load cases have to be considered for analysis:

1.5 (DL + IL)
1.2 (DL + IL ± EL)
1.5 (DL ± EL)
0.9 DL ± 1.5 EL
Earthquake load must be considered for +X, -X, +Y and –Y directions.

Table 1: Details of the Building

Building Parameters	Details
Type of frame	Special RC moment resisting frame fixed at the base
Building plan	38.5m X 35.5m
Number of storeys	30
Floor height	3.5 m
Depth of Slab	225 mm
Size of beam	(300 × 600) mm
Size of column (exterior)	(1250×1250) mm up to story five
Size of column (exterior)	(900×900) mm Above story five
Size of column (interior)	(1250×1250) mm up to story ten
Size of column (interior)	(900×900) mm Above story ten
Spacing between frames	7.5-8.5 m along x - direction 7.5-5.5 m along y - direction
Live load on floor	4 KN/m2
Floor finish	2.5 KN/m2
Wall load	25 KN/m
Grade of Concrete	M 50 concrete
Grade of Steel	Fe 500
Thickness of shear wall	450 mm
Seismic zone	V
Important Factor	1.5
Density of concrete	25 KN/m3
Type of soil	Soft,Medium,Hard Soil Type I=Soft Soil Soil Type II=Medium Soil Soil Type III= Hard Soil
Response spectra	As per IS 1893(Part-1):2002
Damping of structure	5 percent

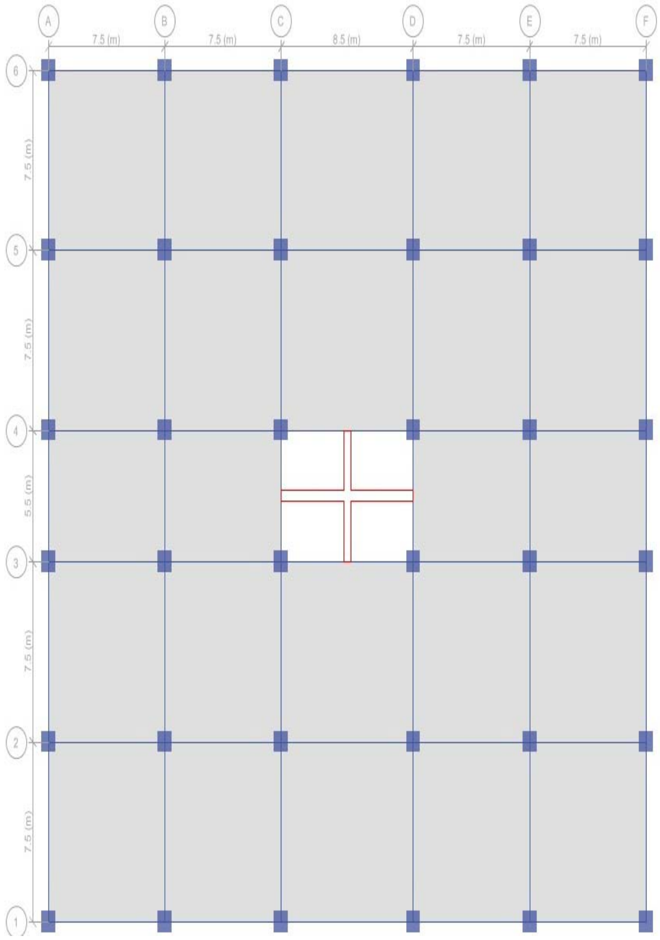

Fig. 1: Plan of the Structure 1

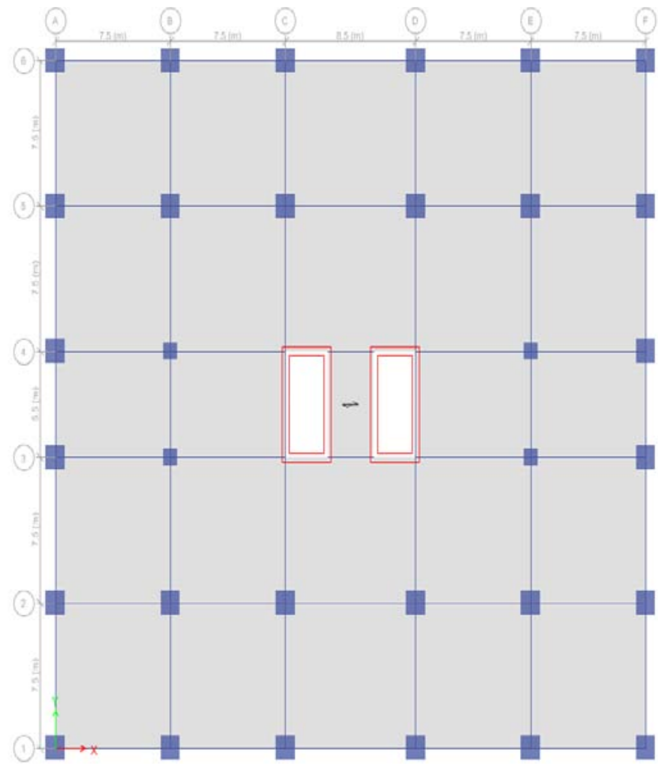

Fig. 3: Plan of the Structure 2

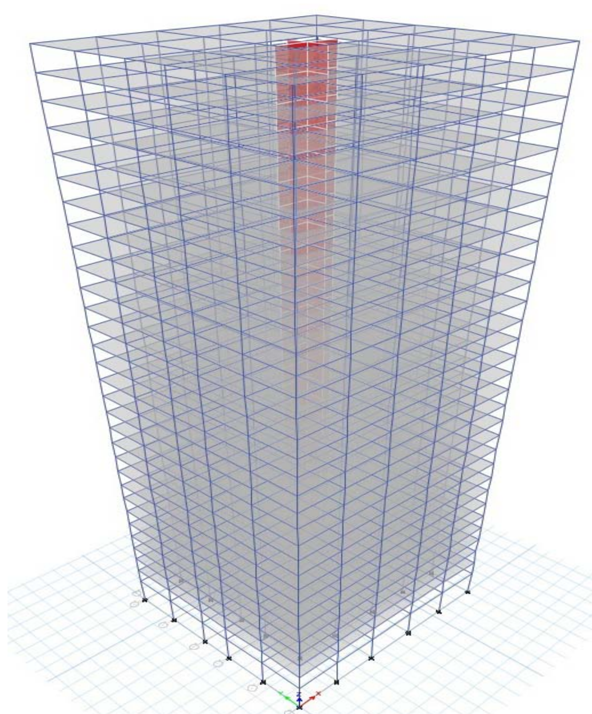
Fig. 2: 3D view showing shear wall location for Structure 1

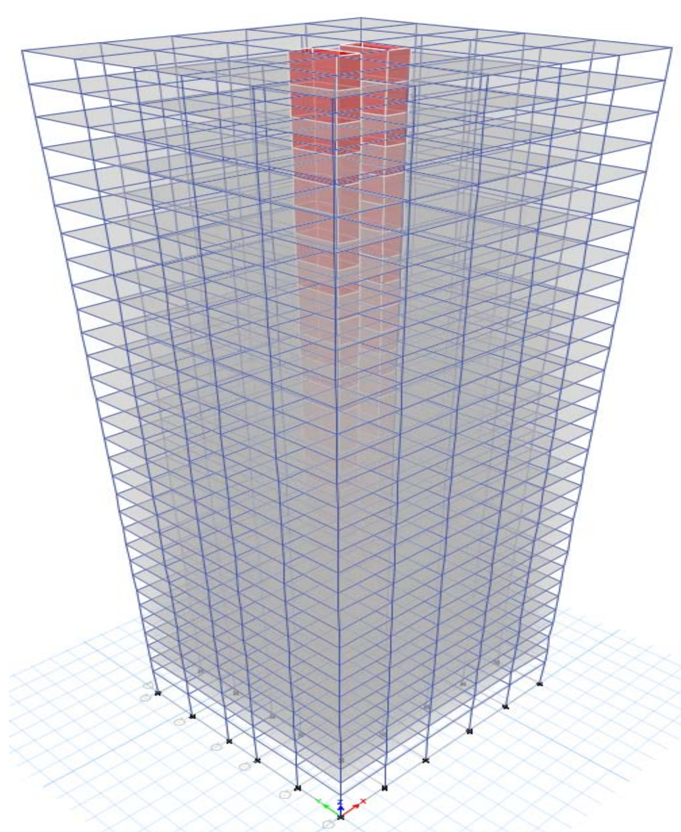
Fig. 4: 3D view showing shear wall location for Structure 2

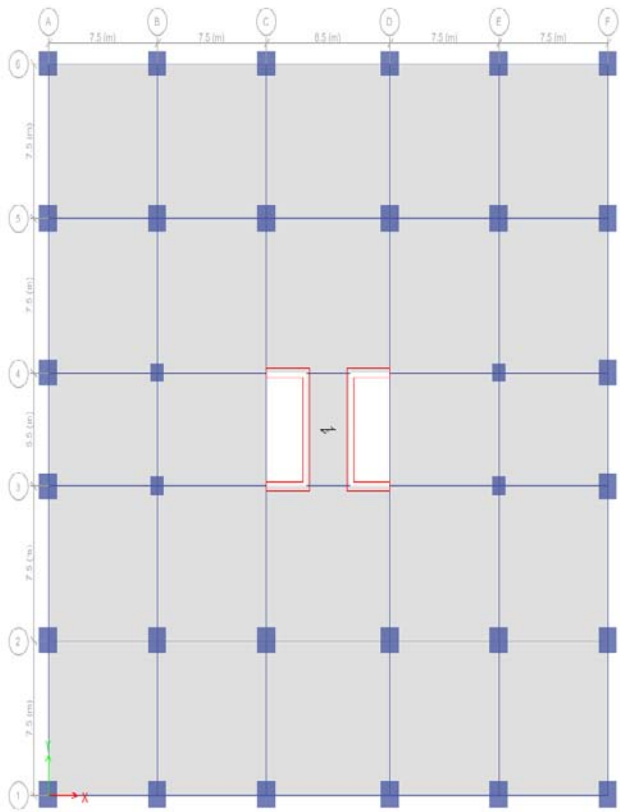

Fig. 5: Plan of the Structure 3

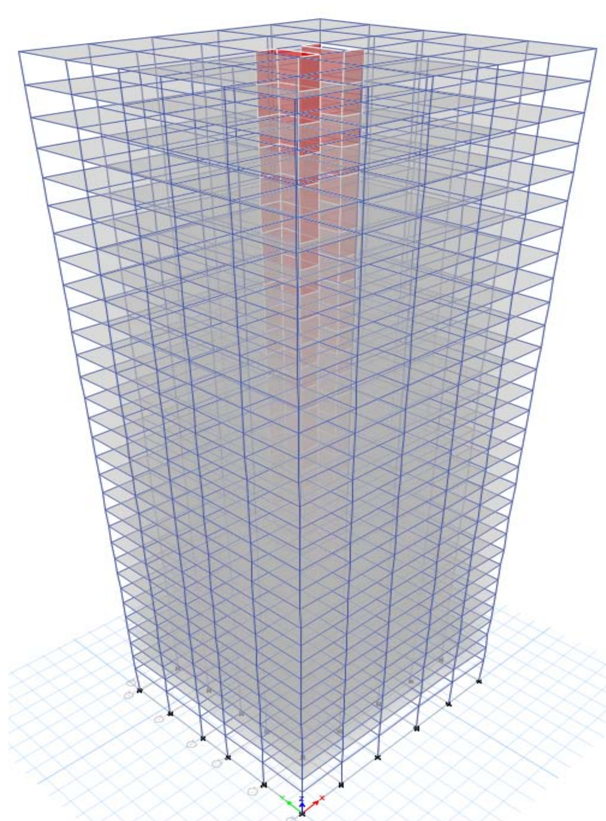

Fig. 6: 3D view showing shear wall location for Structure 3

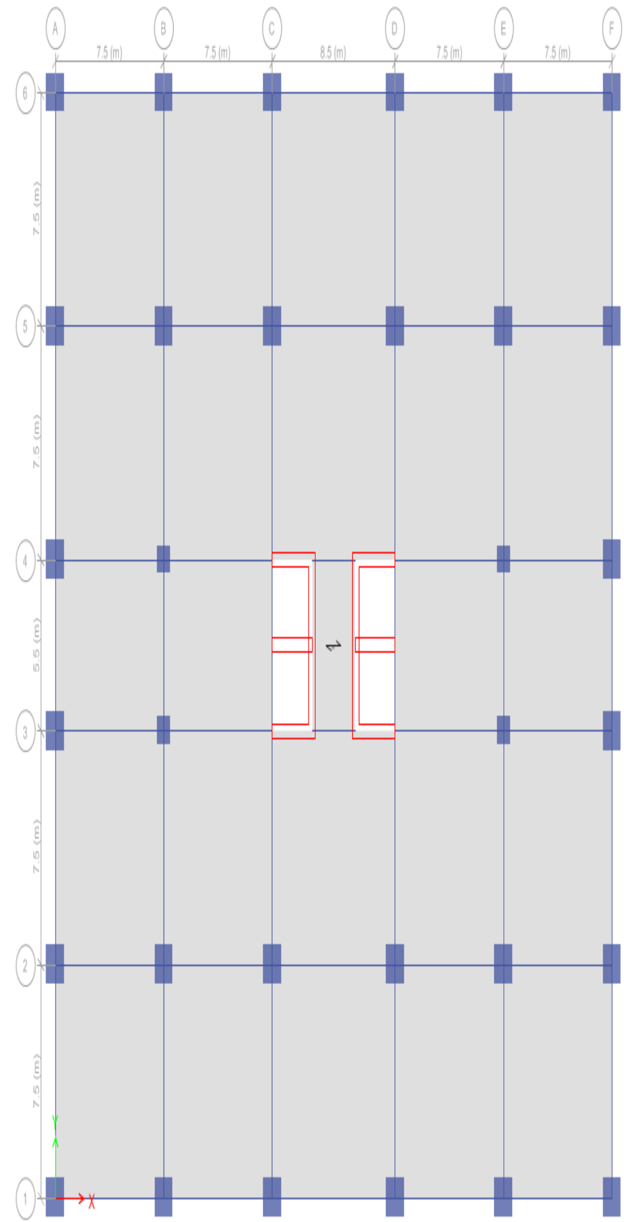

Fig. 7: Plan of the Structure 4

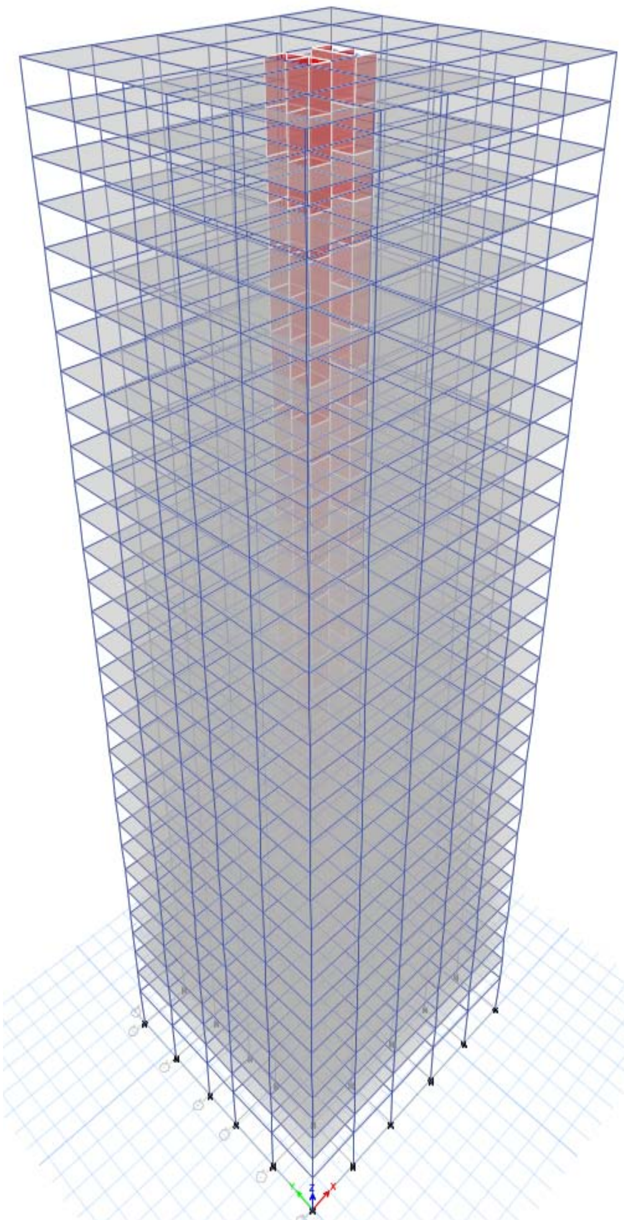

Fig. 8: 3D view showing shear wall location for Structure 4

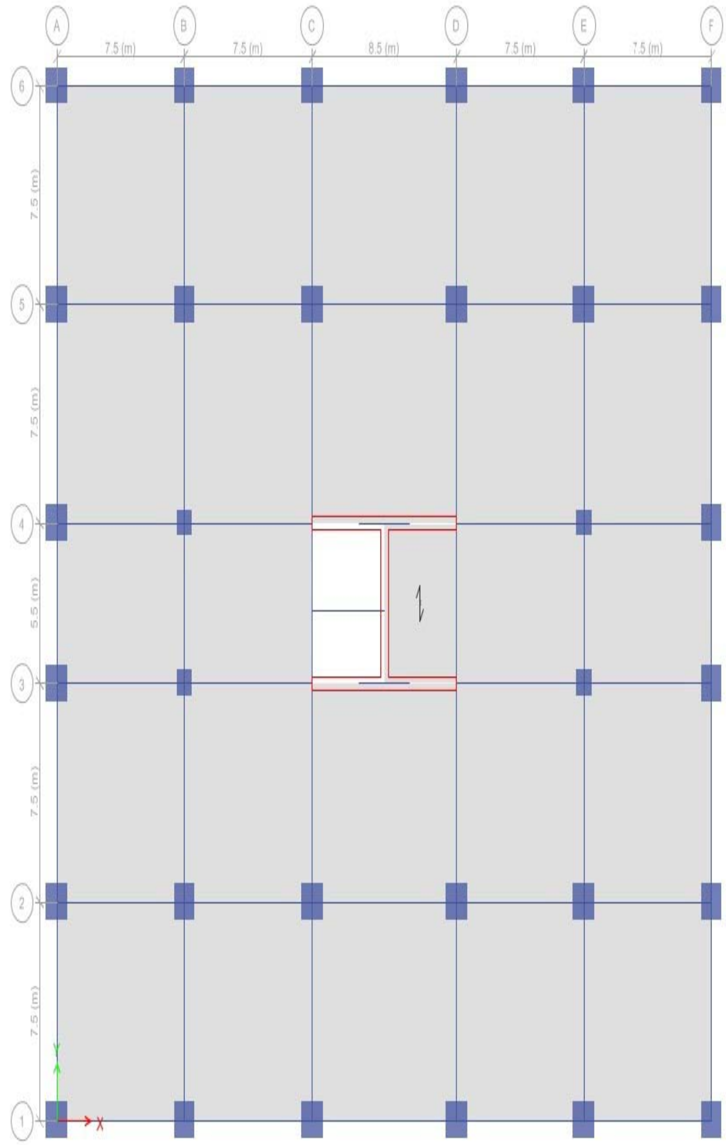

Fig. 9: Plan of the Structure 5

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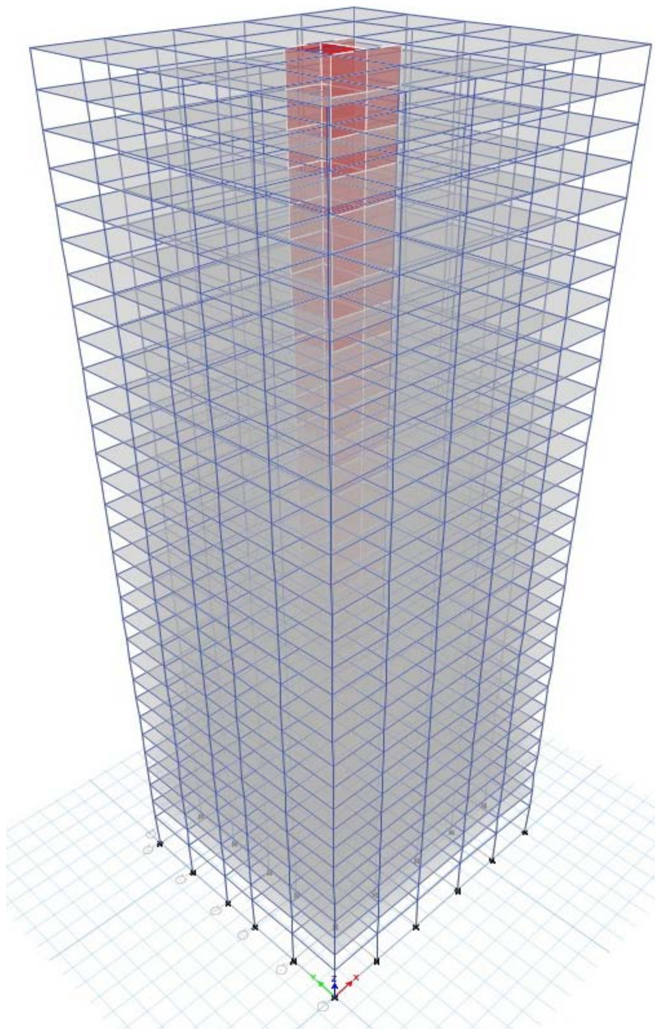


Fig. 10: 3D view showing shear wall location for Structure 5

V. Results and Discussions

Table 2: Pier Axial Force, P for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in soft soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	P	P	P	P	P
				kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	-31716.3887	-33051.4245	-34550.8106	-6497.8574	-33427.2625
1ST	P3	12DLRLLEQXP	Bottom	-31976.2637	-33311.2995	-34810.6856	-6627.7949	-33687.1375
1ST	P3	12DLRLLEQYP	Top	-31716.3887	-25170.9557	-32781.7792	-13631.3189	-33874.5211
1ST	P3	12DLRLLEQYP	Bottom	-31976.2637	-25430.8307	-33041.6542	-13761.2564	-34134.3961

Table 3: Pier Axial Force, P for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	P	P	P	P	P
				kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	-31716.3887	-35888.3932	-35187.6619	-3330.9739	-33266.2891
1ST	P3	12DLRLLEQXP	Bottom	-31976.2637	-36148.2682	-35447.5369	-3460.9114	-33526.1641
1ST	P3	12DLRLLEQYP	Top	-31716.3887	-25170.9557	-32781.7792	-13631.3189	-33874.5608
1ST	P3	12DLRLLEQYP	Bottom	-31976.2637	-25430.8307	-33041.6542	-13761.2564	-34134.4358

Table 4: Pier Axial Force, P for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	P	P	P	P	P
				kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	-31716.3887	-38331.3385	-35736.0616	-983.1011	-33127.6731
1ST	P3	12DLRLLEQXP	Bottom	-31976.2637	-38591.2135	-35995.9366	-1113.0386	-33387.5481
1ST	P3	12DLRLLEQYP	Top	-31716.3887	-25170.9557	-32781.7792	-13631.3189	-33874.595
1ST	P3	12DLRLLEQYP	Bottom	-31976.2637	-25430.8307	-33041.6542	-13761.2564	-34134.47

Table 5: Pier Moment, M for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP)in soft soil

Table: Pier Forces				Structure- 1	Structure -1	Structure -2	Structure -2	Structure - 3	Structure - 3	Structure - 4	Structure - 4	Structure - 5	Structure - 5
Story	Pier	Load Case/Combo	Location	M2	M3	M2	M3	M2	M3	M2	M3	M2	M3
				kN-m	kN-m	kN-m	kN -m	kN -m	kN -m	kN - m	kN-m	kN -m	kN -m
1ST	P3	12DLRLLEQXP	Top	429.3134	-285.376	54.4708	1200.3755	1.9394	237.7991	-17.4689	1861.0597	-65.0181	-61.6944
1ST	P3	12DLRLLEQXP	Bottom	-796.6308	-244.1397	-444.1125	-365.0748	-496.6401	403.2212	21.225	6530.9935	-290.8369	-17.1098
1ST	P3	12DLRLLEQYP	Top	-10.3264	29494.5797	0.9942	19086.5309	0.9679	18817.9303	21.4569	-716.6361	-57.7674	11107.3586
1ST	P3	12DLRLLEQYP	Botbm	4.0607	41193.3422	-3.6328	27973.8752	-4.8413	31627.6809	138.7803	1031.4388	63.9359	34855.9706

Table 6: Pier Moment, M for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure -1	Structure -1	Structure -2	Structure -2	Structure -3	Structure -3	Structure - 4	Structure -4	Structure - 5	Structure - 5
Story	Pier	Load Case/Combo	Location	M2	M3	M2	M3	M2	M3	M2	M3	M2	M3
				kN-m	kN-m	kN-m	kN -m	kN-m	kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	587.5838	-285.376	73.7223	1632.5107	2.2891	323.4068	-25.2213	3005.3081	-67.6274	-71.3796
1ST	P3	12DLRLLEQXP	Bottom	-1084.8797	-244.1397	-602.6852	-496.5017	-673.6876	548.3809	30.6443	8971.8027	-418.5547	-16.379
1ST	P3	12DLRLLEQYP	Top	-10.3264	40215.3638	0.9942	25957.6821	0.9679	25592.3853	30.9946	-716.6361	-57.7665	15118.5325
1ST	P3	12DLRLLEQYP	Bottom	4.0607	56110.8357	-3.6328	38044.4703	-4.8413	43013.646	200.3734	1031.4388	63.9363	47411.0104

Table 7: Pier Moment, M for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure -1	Structure -1	Structure -2	Structure - 2	Structure -3	Structure -3	Structure -4	Structure -4	Structure- 5	Structure -5
Story	Pier	Load Case/Combo	Location	M2	M3	M2	M3	M2	M3	M2	M3	M2	M3
				kN-m	kN-m	kN-m	kN-m	kNm	kN-m	kN- m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	723.8721	-285.376	90.3001	2004.6271	2.5903	397.1246	-30.9703	3853.6925	-69.8743	-79.7196
1ST	P3	12DLRLLEQXP	Bottom	-1333.0941	-244.1397	-739.2339	-609.6748	-826.1452	673.3795	37.6294	10781.7386	-528.5339	-15.7496
1ST	P3	12DLRLLEQYP	Top	-10.3264	49447.15	0.9942	31874.5067	0.9679	31425.9437	38.0596	-716.6361	-57.7657	18572.599
1ST	P3	12DLRLLEQYP	Bottom	4.0607	68956.455	-3.6328	46716.3716	-4.8413	52818.2271	246.0468	1031.4388	63.9367	58222.2947

Table 8: Pier Shear Force, V for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in soft soil

Table: Pier Forces				Structure-1	Structure-1	Structure -2	Structure -2	Structure - 3	Structure - 3	Structure - 4	Structure - 4	Structure - 5	Structure - 5
Story	Pier	Load Case/Combo	Location	V2	V3	V2	V3	V2	V3	V2	V3	V2	V3
				kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
1ST	P3	12DLRLLEQXP	Top	11.7818	-350.2698	-447.2715	-142.4524	47.2635	-142.4513	1334.2668	11.0554	12.7385	-64.5197
1ST	P3	12DLRLLEQXP	Bottom	11.7818	-350.2698	-447.2715	-142.4524	47.2635	-142.4513	1334.2668	11.0554	12.7385	-64.5197
1ST	P3	12DLRLLEQYP	Top	3342.5036	4.1106	2539.2412	-1.322	3659.9287	-1.6598	499.45	33.521	6785.3177	34.7724
1ST	P3	12DLRLLEQYP	Bottom	3342.5036	4.1106	2539.2412	-1.322	3659.9287	-1.6598	499.45	33.521	6785.3177	34.7724

Table 9: Pier Shear Force, V for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure-1	Structure-1	Structure -2	Structure -2	Structure - 3	Structure-3	Structure - 4	Structure-4	Structure-5	Structure - 5
St or y	Pier	Load Case/Combo	Location	V2	V3	V2	V3	V2	V3	V2	V3	V2	V3
				kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
1 ST	P3	12D LRLLEQXP	Top	11.7818	- 477.8467	-608.2892	- 193.2593	64.2783	-193.1362	1704.7127	15.9616	15.7145	-100.2649
1 ST	P3	12D LRLLEQXP	Bottom	11.7818	- 477.8467	-608.2892	- 193.2593	64.2783	-193.1362	1704.7127	15.9616	15.7145	-100.2649
1 ST	P3	12D LRLLEQYP	Top	4541.5634	4.1106	3453.3681	-1.32 2		1.6598	499.45	48.3939	9226.4222	34.7722
1 ST	P3	12D LRLLEQYP	Bottom	4541.5634	4.1106	3453.3681	- 1.322	4977.5031	- 1.6598	499.45	48.3939	9226.4222	34.7722

Table 10: Pier Shear Force, V for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure-1	Structure-1	Structure -2	Structure -2	Structure - 3	Structure-3	Structure - 4	Structure-4	Structure-5	Structure - 5
Stor y	Pier	Load Case/Combo	Location	V2	V3	V2	V3	V2	V3	V2	V3	V2	V3
				kN	kN	kN	kN	kN	kN	kN	kN	kN	kN
1ST	P3	12D LR LLEQXP	Top	11. 7818	- 587. 7046	-746. 9434	- 237. 0097	78. 93	-236. 7816	1979. 4418	19. 5999	18. 2771	-131. 0456
1ST	P3	12D LR LLEQXP	Bottom	11. 7818	- 587. 7046	-746. 9434	- 237. 0097	78. 93	-236. 7816	1979. 4418	19. 5999	18. 2771	-131. 0456
1ST	P3	12D LR LLEQYP	Top	5574. 0871	4. 1106	4240. 5328	-1. 322	6112. 081	-1. 6598	499.45	59. 4249	11328. 4845	34. 7721
1ST	P3	12D LR LLEQYP	Bottom	5574. 0871	4. 1106	4240. 5328	-1. 322	6112. 081	-1. 6598	499.45	59. 4249	11328.4845	34. 7721

Table 11: Pier Torsion, T for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in soft soil

Table: Pier Forces				Structure - 1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	T	T	T	T	T
				kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	-57.8883	-31.8229	-32.2595	-17.3115	-33.9525
1ST	P3	12DLRLLEQXP	Bottom	-57.8883	-31.8229	-32.2595	-17.3115	-33.9525
1ST	P3	12DLRLLEQYP	Top	46.5531	41.9152	92.9513	35.9013	85.1595
1ST	P3	12DLRLLEQYP	Bottom	46.5531	41.9152	92.9513	35.9013	85.1595

Table 12: Pier Torsion, T for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in medium soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	T	T	T	T	T
				kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	-75.9256	-43.2792	-43.873	-24.9942	-46.1738
1ST	P3	12DLRLLEQXP	Bottom	-75.9256	-43.2792	-43.873	-24.9942	-46.1738
1ST	P3	12DLRLLEQYP	Top	66.1147	57.0047	126.4138	51.8336	115.8184
1ST	P3	12DLRLLEQYP	Bottom	66.1147	57.0047	126.4138	51.8336	115.8184

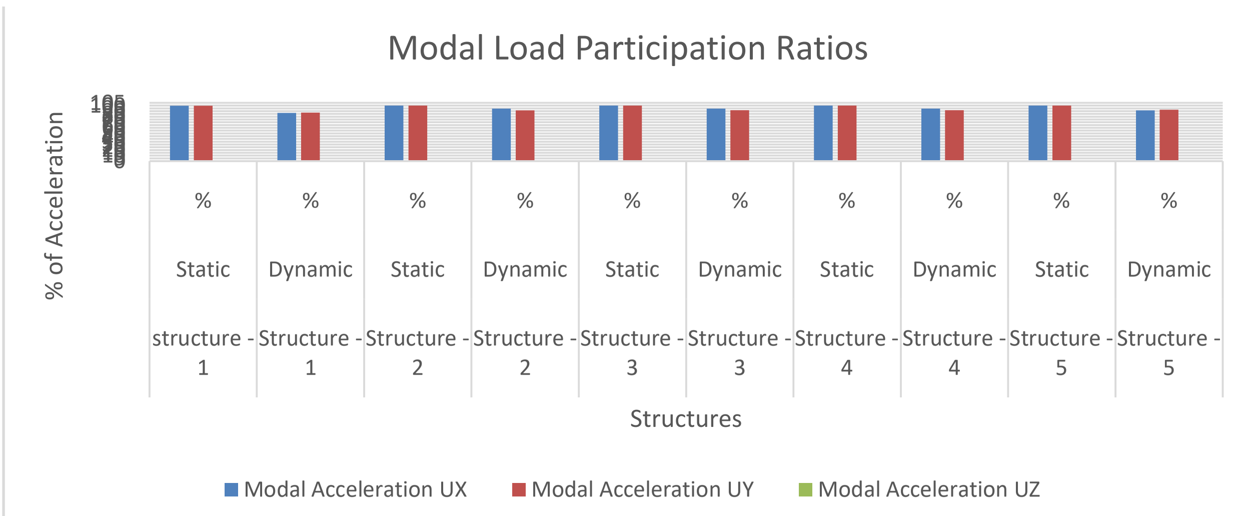
Table 13: Pier Torsion, T for structures with the load combination 1.2 (DL+LL+EQXP) &1.2 (DL+LL+EQYP) in hard soil

Table: Pier Forces				Structure -1	Structure -2	Structure -3	Structure -4	Structure -5
Story	Pier	Load Case/Combo	Location	T	T	T	T	T
				kN-m	kN-m	kN-m	kN-m	kN-m
1ST	P3	12DLRLLEQXP	Top	-91.4578	-53.1443	-53.8734	-30.6914	-56.6977
1ST	P3	12DLRLLEQXP	Bottom	-91.4578	-53.1443	-53.8734	-30.6914	-56.6977
1ST	P3	12DLRLLEQYP	Top	82.9594	69.9984	155.2287	63.6486	142.2192
1ST	P3	12DLRLLEQYP	Bottom	82.9594	69.9984	155.2287	63.6486	142.2192

Table 14: Modal Load Participation Ratios

Table: Pier Forces			Structure-1	Structure-1	Structure-2	Structure-2	Structure-3	Structure-3	Structure-4	Structure-4	Structure-5	Structure-5
Case	Item Type	Item	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic
			%	%	%	%	%	%	%	%	%	%
Modal	Acceleration	UX	99.82	86.71	99.99	94.7	99.98	94.59	99.99	94.54	99.97	91.54
Modal	Acceleration	UY	99.79	87.46	99.98	91.46	99.97	91.85	99.97	91.83	99.97	92.51
Modal	Acceleration	UZ	0	0	0	0	0	0	0	0	0	0

A plot for Modal Load Participation Ratios of Structures in Soft Soil, Medium Soil and Hard Soil has been shown here



Graph 6: Modal Load Participation Ratios of Structures in Soft Soil, Medium Soil and Hard Soil

Table 15: Modal Periods and Frequencies

Structure - 1				Structure -2	Structure -2	Structure - 3	Structure - 3	Structure-4	Structure-4	Structure-5	Structure-5
Case	Mode	Period	Frequency	Period	Frequency	Period	Frequency	Period	Frequency	Period	Frequency
		sec	cyc/sec	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec	sec	cyc/sec
Modal	1	6.298	0.159	5.785	0.173	6.415	0.156	6.375	0.157	6.382	0.157
Modal	2	6.248	0.16	5.606	0.178	6.32	0.158	6.21	0.161	5.694	0.176
Modal	3	5.545	0.18	4.684	0.213	5.767	0.173	5.792	0.173	5.642	0.177
Modal	4	2.062	0.485	1.701	0.588	2.114	0.473	2.102	0.476	2.088	0.479
Modal	5	1.952	0.512	1.547	0.646	1.958	0.511	1.901	0.526	1.565	0.639
Modal	6	1.603	0.624	1.475	0.678	1.568	0.638	1.575	0.635	1.524	0.656
Modal	7	1.191	0.84	0.9	1.112	1.219	0.82	1.212	0.825	1.19	0.84
Modal	8	1.027	0.974	0.838	1.193	1.028	0.972	0.983	1.017	0.791	1.264
Modal	9	0.803	1.245	0.645	1.551	0.82	1.22	0.815	1.226	0.711	1.406
Modal	10	0.782	1.279	0.613	1.632	0.711	1.406	0.714	1.401	0.703	1.423
Modal	11	0.645	1.55	0.5	2.002	0.641	1.56	0.604	1.656	0.565	1.769
Modal	12	0.581	1.72	0.45	2.222	0.592	1.689	0.589	1.697	0.423	2.363

VI. Discussion on Results

When a structure is subjected to earthquake, it responds by vibrating. An example force can be resolved into three mutually perpendicular directions-two horizontal directions (X and Y directions) and the vertical direction (Z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are primarily designed for gravity loads-force equal to mass time's gravity in the vertical direction. Because of the inherent factor used in the design specifications, most structures tend to be adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans those in which stability for design, or for overall stability analysis of structures. The basic intent of design theory for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage, resist moderate earthquakes without structural damage but with some non-structural damage. To avoid collapse during a major earthquake, Members must be ductile enough to absorb and dissipate energy by post elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the event of the failure of key elements. When the primary element or system yields or fails, the lateral force can be redistributed to a secondary system to prevent progressive failure.

The result obtained from the analysis models will be discussed and compared as follows:

It is observed that

- The time period is 6.298 Sec for structure1 and it is same for different type of soil.
- The Frequency is 0.159 cyc/sec for structure1 and it is same for different type of soil.
- The time period is 5.785 Sec for structure2 and it is same for different type of soil.
- The Frequency is 0.173 cyc/sec for structure2 and it is same for different type of soil.
- The time period is 6.415 Sec for structure3 and it is same for different type of soil.
- The Frequency is 0.156 cyc/sec for structure3 and it is same for different type of soil.
- The time period is 6.375Sec for structure4 and it is same for different type of soil.
- The Frequency is 0.157 cyc/sec for structure4 and it is same for different type of soil.
- The time period is 6.382 Sec for structure5 and it is same for different type of soil.
- The Frequency is 0.157 cyc/sec for structure5 and it is same for different type of soil.

It is observed that

Shear Wall forces (Pier Forces) for structure 1

- For the Pier axial forces in X direction There is not considerable difference for soft Soil, Medium soil & Hard soil.
- Pier Moment M2 in X direction for soft soil <medium soil < hard soil.
- Pier Moment M3 in X direction for soft soil =medium soil = hard soil.
- Pier Moment M2 in Y direction for soft soil =Medium soil = hard soil.
- Pier Moment M3 in Y direction for soft soil <Medium soil < hard soil.
- Pier Shear Forces V2 in X direction for soft soil =Medium soil = hard soil.
- Pier Shear Forces V3 in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in Y direction for soft soil <Medium soil < hard soil

It is observed that

Shear Wall forces (Pier Forces) for structure 2

- Pier axial forces in X direction for soft Soil >Medium soil > Hard soil
- Pier Moment M2 in X direction for soft soil <medium soil < hard soil .
- Pier Moment M3 in X direction for soft soil <medium soil < hard soil .
- Pier Moment M2 in Y direction for soft soil =Medium soil = hard soil .
- Pier Moment M3 in Y direction for soft soil <Medium soil < hard soil .
- Pier Shear Forces V2 in X direction for soft soil >Medium soil > hard soil.
- Pier Shear Forces V3 in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in Y direction for soft soil <Medium soil < hard soil.

It is observed that

Shear Wall forces (Pier Forces) for structure 3

- Pier axial forces in X direction for soft Soil >Medium soil > Hard soil
- Pier Moment M2 in X direction for soft soil <medium soil < hard soil.
- Pier Moment M3 in X direction for soft soil <medium soil < hard soil.
- Pier Moment M2 in Y direction for soft soil =Medium soil = hard soil.
- Pier Moment M3 in Y direction for soft soil <Medium soil < hard soil.
- Pier Shear Forces V2 in X direction for soft soil <Medium soil < hard soil.

- Pier Shear Forces V3 in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in Y direction for soft soil <Medium soil < hard soil.

It is observed that

Shear Wall forces (Pier Forces) for structure 4

- Pier axial forces in X direction for soft Soil <Medium soil < Hard soil
- Pier Moment M2 in X direction for soft soil >medium soil > hard soil.
- Pier Moment M3 in X direction for soft soil <medium soil < hard soil.
- Pier Moment M2 in Y direction for soft soil <Medium soil < hard soil.
- Pier Moment M3 in Y direction for soft soil >Medium soil > hard soil.
- Pier Shear Forces V2 in X direction for soft soil <Medium soil < hard soil.
- Pier Shear Forces V3 in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in Y direction for soft soil <Medium soil < hard soil.

It is observed that

Shear Wall forces (Pier Forces) for structure 5

- Pier axial forces in X direction for soft Soil <Medium soil < Hard soil
- Pier Moment M2 in X direction for soft soil >medium soil > hard soil.
- Pier Moment M3 in X direction for soft soil >medium soil > hard soil.
- Pier Moment M2 in Y direction for soft soil =Medium soil = hard soil.
- Pier Moment M3 in Y direction for soft soil <Medium soil < hard soil.
- Pier Shear Forces V2 in X direction for soft soil <Medium soil < hard soil.
- Pier Shear Forces V3 in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in X direction for soft soil >Medium soil > hard soil.
- Pier Torsion in Y direction for soft soil <Medium soil < hard soil.

VII. Conclusions

In this paper, reinforced concrete shear wall buildings were analyzed with the procedures laid out in IS codes. Seismic performance of building model is evaluated.

From the above results and discussions, following conclusions can be drawn:

- Building with box shape Shear Walls provided at the center core showed better performance in terms of Pier Forces.
- The shear wall and it is position has a significant influenced on the time period. The time period is not influenced by the type of soil.
- There is considerable difference in Pier Moment with a Different type of soils and structures.
- There is considerable difference in Pier shear force with a Different type of soils and structures.
- There is not considerable difference in Pier axial forces with a Different type of soils and structures.
- It is evident that Pier Torsion in X direction for all structures in soft soil more than Medium soil and more than hard soil.
- It is evident that Pier Torsion in Y direction for soft soil less than Medium soil and less than hard soil.
- shear is effected marginally by placing of the shear wall, grouping of shear wall and type of soil. The shear is increased by adding shear wall due to increase the seismic weight of the building.
- The moment resisting frame with shear walls are very good in lateral force such as earthquake and wind force. The shear walls provide lateral load distribution by transferring the wind and earthquake loads to the foundation. And also impact on the lateral stiffness of the system and also carries gravity loads.
- It is evident that shear walls which are provided from the foundation to the rooftop, are one of the excellent mean for providing earthquake resistant to multistory reinforced building with different type of soil.
- The vertical reinforcement that is uniformly distributed in the shear wall shall not be less than the horizontal reinforcement .This provision is particularly for squat walls (i.e. Height-to-width ratio is about 1.0).However ,for walls whit height-to-width ratio less than 1.0, a major part of the shear force is resisted by the vertical reinforcement. Hence, adequate vertical reinforcement should be provided for such walls.
- Based on the analysis and discussion ,shear wall are very much suitable for resisting earthquake induced lateral forces in multistoried structural systems when compared to multistoried structural systems whit out shear walls. They can be made to behave in a ductile manner by adopting proper detailing techniques.
- According to IS-1893:2002 the number of modes to be used in the analysis should be such that the total sum of modal masses of all modes considered is at least 90 percent of the total seismic mass. Here the maximum mass for structure 2 is 94.7 percent and minimum mass for structure 1 is 86.71 percent.

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Mechanical Behavior of Cement Stabilized Dredged Soil

By Obaid Qadir Jan & B. A. Mir

Abstract- Dredged soil is a solid waste generated from the dredging of a river and possesses low bearing capacity and high compressibility. Concern over environmental effects of dredging, disposal and the increasing unavailability of suitable disposal sites, has put pressure for characterization of this material. This material can be a valuable resource for many practical purposes such as fill material, sub-grade construction, reclamation, landscaping, agriculture, landfill covers, constructing wetlands for water quality improvement, creation of islands, wildlife habitat wetlands, and amongst others. In this study, various in-situ and disturbed soil samples were collected from three different sites of flood channel of river Jhelum in Srinagar. Various soil tests like gradation, specific gravity, consistency indexes, light compaction, unconfined compressive strength, and direct shear tests were conducted. The results of three samples were compared and the weakest soil sample was selected for cement treatment. The cement was added to the dredged soil in varying percentages of 4%, 8%, 12% and 16%. The treated soil samples were subjected to consistency limit tests, direct shear tests and unconfined compressive strength at immediate, 7 days and 28 days of curing period. The test results revealed that the plasticity index increased with cement content.

Keywords: cement; dredged soil; flood channel; mechanical properties; solid waste.

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MECHANICALBEHAVIOROFCEMENTSTABILIZEDDREDGEDSOIL

Strictly as per the compliance and regulations of:

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Obaid Qadir Jan [α] & B. A. Mir [σ]

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Keywords: cement; dredged soil; flood channel; mechanical properties; solid waste.

I. Introduction

Soft soil deposits usually have a low bearing capacity and undergo excessive settlement over a long period of time. Such soil deposits pose a great challenge to geotechnical engineers as both safety and serviceability requirements may not be satisfied (Mir 2015). Dredged soil is one such soft soil deposit of solid waste generated by dredging of a river. The present study deals with dredged soil generated by the dredging of flood spill channel of river Jhelum in Srinagar. The river Jhelum rises from the Verinag Spring situated at the foot of the Pir Panjal in the south-eastern part of the valley of Kashmir. It flows through Srinagar and the Wular lake before entering Pakistan through a deep narrow gorge. Jhelum is the lifeline of the city of Srinagar, flowing through the Kashmir valley giving it pristine glory, essentially forming the backbone of all its economic activities. However, the Jhelum river has also been a source of worry for the people of Kashmir, as frequent small and large scale floods have been reported throughout its history. One such floods of unprecedented magnitude in decades was witnessed in September 2014, killing nearly 277 people in India and 280 in Pakistan. Due to the deposition of sediment and silt carried by the river during its normal course and floods the carrying capacity of the river reduced drastically. In such a scenario, there is a dire need for dredging of the river bed to enhance its carrying capacity. But due to dredging of the river Jhelum and flood spill channel there is accumulation of the dredged material, which causes not only the serious health and environmental problems, but also disposal problems due to scarcity of proper disposal sites (Mir 2005). Dredged material is an under-utilized resource that can be used for beneficial purposes once physical, engineering, chemical or biological properties are determined (DOER 1999). Therefore, there is a dire need for stabilization of this dredged material that can be used in aquatic environments like habitat creation, erosion control (underwater berms made of geotextile tubes filled with dredged material), construction of dikes, augmenting decreasing wetland resources including freshwater and saltwater marshes, bio filters for landfill leachate, constructed wetlands for waste water treatment, or fill for sloughs in riverine areas or denuded reservoir banks. There are a vast number of beneficial uses in upland areas including construction of roads or airport runways, landscaping (manufactured soil products), parks and recreational area development, cemetery development, and others. In the present investigation an attempt has been made to improve the mechanical behavior of dredged soil using ordinary Portland cement. Test results reveal significant improvement in the engineering properties of dredged soil. All products made from dredged material will have to meet the performance specifications established for existing material and will have to be cost competitive, available in a timely manner, and tested for

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performance. Therefore, this study presents the effect of cement stabilization on geotechnical properties of dredged material for its bulk utilization. The main contributions of this study to practice are on quantifying improvement in mechanical behavior due to cement treatment and highlighting the fact that higher percentages of cement could turn stabilization from beneficial to an extremely dangerous practice.

II. Materials and Methods

In this study, various soil samples from three different sites of the flood channel were collected. The disturbed samples were subjected to various soil tests like gradation, specific gravity, light compaction tests. Consistency limits were performed on both oven dried and air dried samples to check for the organic content. Unconfined compressive strength and direct shear tests were conducted on in-situ samples to determine shear strength parameters as per the Standard Codal procedures. After geotechnical evaluation of the physical and mechanical properties, the weakest soil sample was selected for cement stabilization using commonly available ordinary Portland cement (OPC) conforming to a compressive strength of 43 MPa. The fineness test conducted on the cement revealed a fineness value of 2 %. The standard consistency of the cement was determined using Vicat's plunger apparatus and a value of 31 % was observed. The physical properties of the selected soil sample are given in Table 1. Test specimens were prepared with dredged soil using a range of cement from 4% to 16 % (with 4 % increment by dry weight of the soil) at γ_{dmax} and optimum moisture content. The specimens were subjected to tests on consistency limits, direct shear parameters and unconfined compressive strength tests at immediate, 7 days and 28 days of curing period.

a) Cement stabilization of soils

The chemical stabilization of clays using cement is a common method that can be used to improve properties of soil to provide a workable platform for construction projects (Brandon et al., 2009). Cement is often used as an additive to improve the strength and stiffness of soft clayey soils (Lee 1991, Mitchell, 1981). Soil-cement is widely used to improve foundations of structures, in basement improvement, in rigid and flexible highway, airfield pavements, in embankment slope protection, stream bank protection, waterproofing, grade control structures, and reservoir and channel linings (Ingles et al 1972, Williams 1986, Teng et al 1973). The role of hydraulic cement such as portland or slag cement is to bind soil particles together, improve compaction, and decrease void spacing, improve the engineering properties of available soil such as, unconfined compressive strength, modulus of elasticity, compressibility, permeability, the drying rate, workability, swelling potential, frost susceptibility and sensitivity to changes in moisture content (Leonards 1962, Woods 1960, Robert et al 1971). Cement can be used to stabilize any type of soil, without those having organic content greater than 2% or having pH lower than 5.3 (ACI 230.1R-90 1990).

i. *Mechanism of cement stabilization*

The fundamental mechanism of soil cement stabilization has been outlined by Schaefer et al (1997), amongst others. The components of Portland cement are tricalcium silicate (C_3S), dicalcium silicate (C_2S), tricalcium aluminate (C_3A) and tetracalcium alumino-ferrite (C_4A) (Lea, 1956). These four main constituents are major strength producing components.

Table 1: Physical properties of dredged soil

Properties	Results
In-situ water content w_n (%)	36.8
Permeability Coefficient, k (m/sec)	1.2×10^{-8}
Field dry density γ_d (kN/m^3)	13.8
Specific gravity (G)	2.69
Clay (%)	15.9
Silt (%)	79.6
Sand (%)	3.7
Gravel (%)	0.80
Coefficient of uniformity, C_u	--
Coefficient of curvature, C_c	--
Suitability number, S_n	--
Liquid limit L_L (%)	38.5
Plastic limit P_L (%)	28.1
Shrinkage limit (%)	17.3
Plasticity index PI (%) (L_L-P_L)	10.4
PI A_{-line} (%)	13.5
PI U_{-line} (%)	27.4
Classification	MI
Clay mineral	Kaolonite
Flow index, I_f	10.2
Toughness index, I_T	1.0
Activity	0.7
Consistency index, I_c	0.2
In-situ UCS, q_u (kN/m^2)	34.7
In-situ Cohesion, c_u (kN/m^2)	23.7
Angle of Friction, ϕ^o	16.1
Optimum moisture content, (%)	26
Max^m dry unit weight, (kN/m^3)	15.4
Un soaked CBR (%)	2.6
Soaked CBR (%)	2.4

The major reactions that result in increase in strength of soft soil are:

1. Calcium hydroxide will be formed when quick lime reacts with water as a result pH increases.
2. Isomorphous substitution of calcium in the clay particles decrease the interlayer spacing and cause coagulation of the clay particles, thus reducing the plasticity of the soil.
3. Calcium silica hydrate(C-S-H) compounds are formed by the dissolution of silica in the clay

particles followed by its reaction with calcium oxide. These compounds form bonds between binder particles or between binder particles and soil particles to form stiff matrix. The composition and structure of the C-S-H gel and the type and amount of other hydration products can alter due to presence of organic matter in soil.

The reactions that take place in soil cement stabilization can be represented in the following equations, the reactions given here are for tricalcium silicate (C_3S) only, because it is the most important constituent of Portland cement.

$$C_3S + H_2O \longrightarrow C_3S_2H_x \text{ (hydrated gel)} + Ca(OH)_2 \quad (1)$$

Primary cementitious product

$$Ca(OH)_2 \longrightarrow Ca^{2+} + 2\,OH^- \quad (2)$$

$$Ca^{2+} + 2\,OH^- + SiO_2 \longrightarrow CSH \quad (3)$$

Secondary cementitious product

$$Ca^{2+} + 2\,OH^- + Al_2O_3 \longrightarrow CAH \quad (4)$$

Secondary cementitious product

In order to have additional bonding forces produced in the cement-clay matrix, the silicates and aluminates in the compound matrix must be soluble. In the above equations, the strength of the primary cementitious products is much stronger than the secondary ones. The cement hydration and the pozzolanic reactions can last for months or even years after the mixing and thus the strength of cement treated clay are expected to increase with time (Bergado et al., 1996). Thus, in the soil cement reactions, primary and secondary cementing substances are formed. The primary products harden into high-strength additives. The secondary processes increase the strength and durability of the soil cement by producing an additional cementing substance to further enhance the bond strength between the particles.

III. Results and Discussions

a) Effect of cement on consistency limits

The addition of first increment of 4% cement on dredged soil increases the liquid limit, plastic limit, and plasticity index as shown in Fig. 1. This improvement of liquid limit attributed that more water is required for the cement treated soil to make it fluid and the increase of plastic limit implies that cement treated soil required more water to change it plastic state to semisolid state (Sarkar et al 2012). When final increment of 16 % cement is mixed to the dredged soil all the consistency limits decrease with plasticity index reporting a value of 11.1 which is higher than the untreated value of 10.4 (Table 2). This suggests that the addition of cement to the dredged soil made the soil more plastic making it difficult to work with.

Table 2: Consistency limits of cement treated soil

Cement (%)	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
0	38.5	28.1	10.4
4	51.3	34.1	17.2
8	48.2	33.8	14.4
12	49.6	35.9	13.7
16	45.4	34.3	11.1

b) Effect of cement on compaction characteristics of dredged soil

One of the basic and least expensive construction procedures used for soil stabilization is compaction. Compaction improves the engineering properties of foundation material so that the required shear strength is obtained. Generally, a high level of compaction of soil enhances the geotechnical parameters of the soil, so that achieving the desired degree of relative compaction necessary to meet specified or desired properties of soil is very important (Nicholson 1994). The OMC of cement stabilized soil varies in a very narrow range (Fig. 2). From Fig. 3 it is seen that OMC decreases and MDD increases continuously up to 16 % cement content without giving any optimum value.

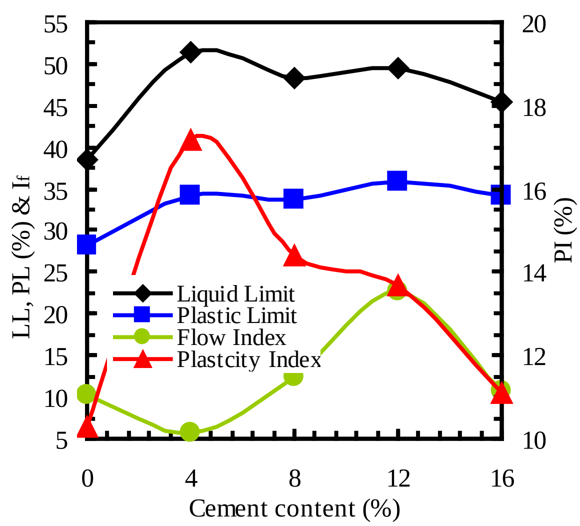

Fig. 1: Variation of consistency parameters

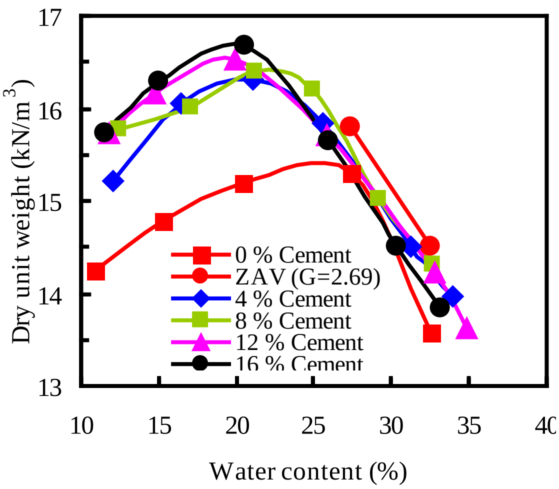

Fig. 2: Compaction curves of cement treated soil

c) *Effect of cement on strength characteristics of dredged soil*

Strength characteristics are fundamental for any engineering application of the soil. In this study unconfined compression tests and direct shear tests were conducted on the cement stabilized dredged soil. The test results are discussed below:

i. *Unconfined compression test*

Unconfined compression test is the simplest and quickest method to determine the shear strength of cohesive soils. Test specimens were prepared, compacted under standard compaction at γ_{dmax} and optimum moisture content. The samples were tested immediately, 7 days and after 28 days of curing period (Fig. 4a, 4b, 4c).

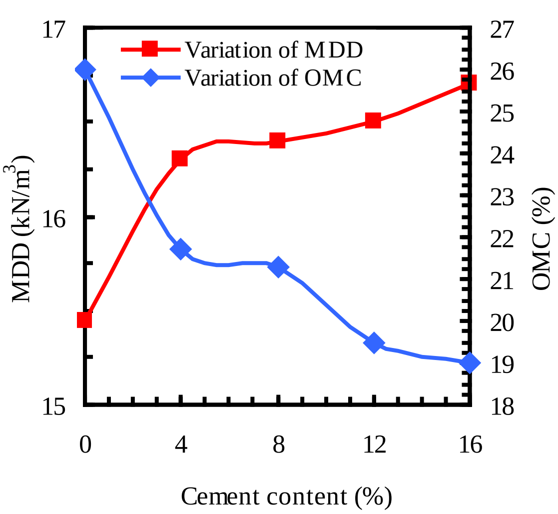

Fig. 3: Variation of OMC and MDD with cement content

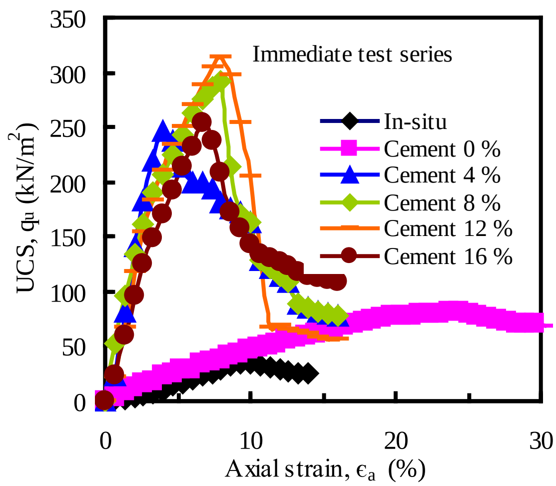

Fig. 4(a): Stress strain curves for cement stabilized dredged soil at immediate test series

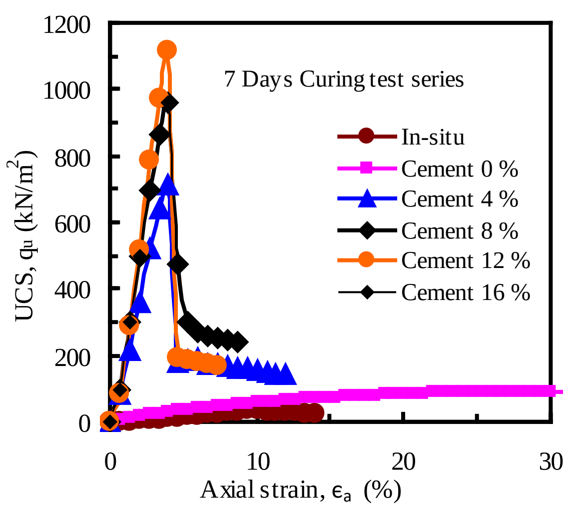

Fig. 4(b): Stress strain curves for cement stabilized dredged soil at 7 days curing period

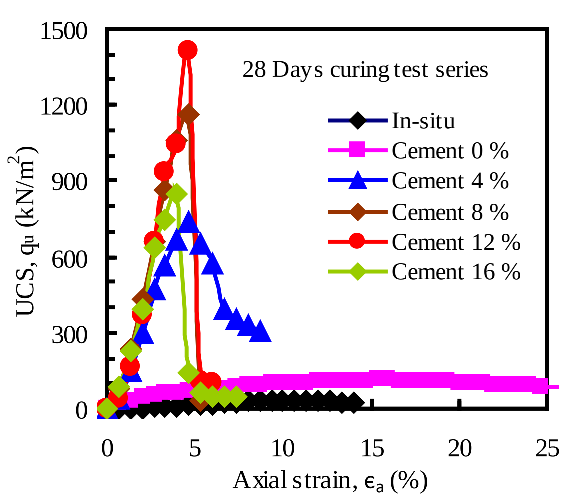

Fig. 4(c): Stress strain curves for cement stabilized dredged soil at 28 days of curing period

The test results revealed that addition of cement has significant effect on the strength gain of the dredged soil. The optimum cement content has been found out to be 12 % (Fig. 5). With increase in curing period the strength of the dredged soil increased from 115 kPa to 1412 kPa (Fig. 5). Thus the cement treatment improves the soil consistency from soft in in-situ state to hard in treated state.

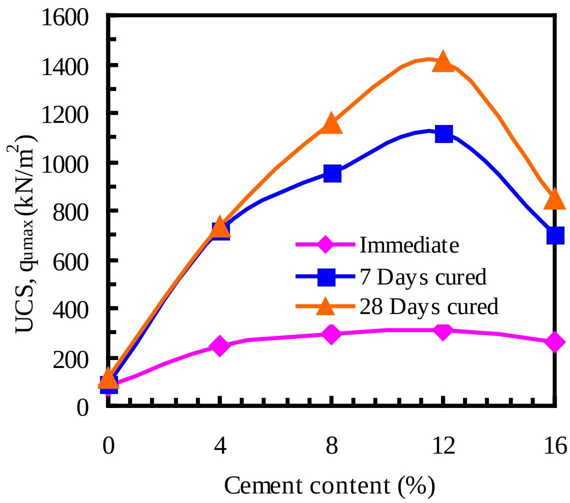

Fig. 5: Effect of curing period on the strength of dredged soil with change in cement content

ii. *Direct shear test*

Direct shear tests were conducted on untreated and treated test specimens. The specimens were prepared, compacted under standard compaction at γ_{dmax} and optimum moisture content. The test results reveal that in-situ dredged soil exhibits soft consistency. The angle of internal friction of 16 degrees indicates loose denseness of the soil. However, cement treatment drastically improves both cohesion (c) and frictional shearing angle (ϕ) as shown in Fig. 7 changing the soil state from loose to dense state. The shear parameters showed decreasing trend beyond 12 % cement content. The variation of c and ϕ with increase in cement content is shown in Fig. 7.

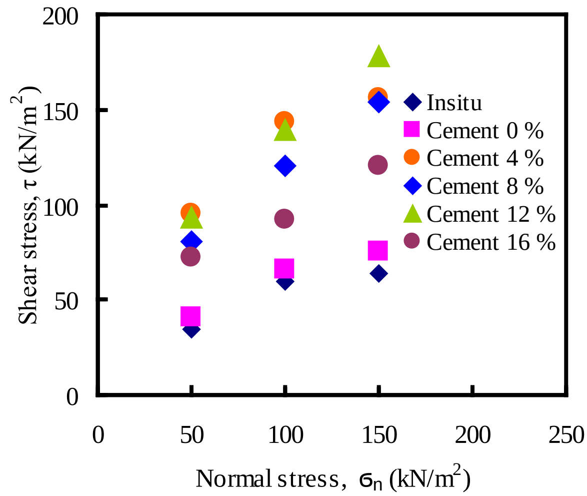

Fig. 6: Strength envelope for cement stabilized dredged soil

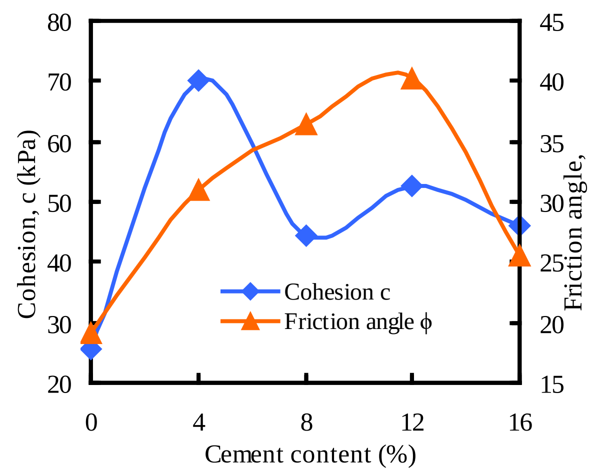

Fig. 7: Variation of c and ϕ with change in cement content

IV. Conclusions

The addition of cement to the dredged material proved an effective means of improving the engineering properties of soils. The unconfined compressive strength increased by about 15 % than the untreated soil. The liquid limit, plastic limit, however showed varying trend, increasing the plasticity index, suggesting that the soil becomes less workable on mixing with cement. The Mohr Coloumb parameters showed significant gain, improving the soil consistency from soft to hard state and soil state from very loose to dense. Thus, using dredged soil as a resource has a twofold advantage. First, to avoid the serious health and environmental problems caused by large scale dumping of this material and second to use the treated dredged material as an engineering construction material for various applications.

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Parametric Study of the Stabilization of Sloped Surfaces Bedding with Geotextiles

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Abstract- One of the most important applications of geotextiles is as a reinforcement to increase the stability and strength in soil slopes as well as to stabilize slopes which would be unstable without reinforcement. This paper presents the results of a parametric study which investigated the effects of various factors, such as the number of reinforcement layers and a dike's slope angle, on the dike's safety factor. Using PLAXIS software and the finite element method, the maximum final displacement, maximum horizontal displacement, maximum vertical displacement, and maximum shear strain which are created in a dike were examined. The results show that as the number of reinforcement layers was increased, the dike's safety factor increased and the maximum final displacement, maximum horizontal displacement, maximum vertical displacement and maximum shear strain created in the dike decreased. Furthermore, as the dike's slope angle increased, the safety factor of the dike's stability decreased and the maximum final displacement, maximum horizontal displacement, maximum vertical displacement, and maximum shear strain created in the dike increased.

Keywords: geotextile, reinforcement, finite element, dike.

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PARAMETRICSTUDYOFTHESTABILIZATIONOFSLOPEDSURFACESBEDDINGWITHGEOTEXTILES

Strictly as per the compliance and regulations of:

Parametric Study of the Stabilization of Sloped Surfaces Bedding with Geotextiles

Hamid Fathi Shoob [α], Amin Nooralizadeh [σ] & Hamed Zamenian [ρ]

Abstract- One of the most important applications of geotextiles is as a reinforcement to increase the stability and strength in soil slopes as well as to stabilize slopes which would be unstable without reinforcement. This paper presents the results of a parametric study which investigated the effects of various factors, such as the number of reinforcement layers and a dike's slope angle, on the dike's safety factor. Using PLAXIS software and the finite element method, the maximum final displacement, maximum horizontal displacement, maximum vertical displacement, and maximum shear strain which are created in a dike were examined. The results show that as the number of reinforcement layers was increased, the dike's safety factor increased and the maximum final displacement, maximum horizontal displacement, maximum vertical displacement and maximum shear strain created in the dike decreased. Furthermore, as the dike's slope angle increased, the safety factor of the dike's stability decreased and the maximum final displacement, maximum horizontal displacement, maximum vertical displacement, and maximum shear strain created in the dike increased.

Keywords: geotextile, reinforcement, finite element, dike.

I. Introduction

Reinforced soil and face walls have received a great deal of attention in recent years in urban construction and the related road and rail networks for trench stability as well as for access to dikes (Skinner and Row 2006). Geosynthetics are widely used as reinforcement components due to their many advantages, such as ease of use and economic benefits (Leshchinsky and Han 2004). Two of its common applications are soil reinforcement and securing the stability of dikes. Geosynthetics can prevent the extension of rupture levels by increasing the tensile resistance of the soil and by creating friction between the reinforcement and the soil to increase the stability and safety of dikes (Hatami and Bathurst 2006).

Many studies have been carried out to determine the geotechnics of reinforced sloped dikes in the last 25 years. Vidal (1969) proposed using dike reinforcement mechanisms to solve many geotechnical issues. On the other hand, using the finite element method in simulating dikes reinforced by polymer materials such as geosynthetics, under static and dynamic loads are capable of producing acceptable results as well. For example, using the finite element method, Ling et al. (2004) analyzed a face wall reinforced with geosynthetics and compared it to the experimental results, which suggested that the finite element method was highly accurate. Siavoshnia et al. (2010) evaluated the performance of a dike reinforced by geotextile fibers that was built on soft clay soil and modeled it using PLAXIS 2D. Their results show that a decrease in the dike's slope and its height from the bedding, as well as an increase in the hardness of the geotextile layers, led to a decrease in the dike's settlement. George and Hataf (2000) using PLAXIS, modelled the foundation of a soil barrier that was comprised of a column of sandy soil reinforced by geotextile layers. The results of their study showed that the geotextile layers led to an increase in the load-bearing capacity of the soil; however, using this system in very soft soils that contain organic materials resulted in decreased settlement of the foundation. Naini and Mirzakhanlari (2008) investigated the effect of strengthening granular soil with geotextiles and found that the load-bearing capacity of granular soils reinforced by geotextiles significantly increased the load-bearing capacity in the normal case. Ghaderi et al. (2005) examined the parameters that influence sloped fills reinforced by geotextile fibers. Their investigations showed that the stress distribution in the fill height was independent of the length of the geotextile layers. They also found that an increase in the length and number of geotextile layers led to an increase in the dike's safety factor against sliding. Noorzad and Mirmoradi (2010) investigated clay soils reinforced by geotextiles. Their experimental results showed that when the soil moisture increased, the soil's maximum tolerable stress decreased for both the "with" and "without" geotextile cases, but the axial strain increased and caused a rupture. Furthermore, an increase in the soil compaction resulted in increased resistance and soil axial strain in both cases.

II. Materials and Modeling Specifications

In the parametric study presented in this paper, the dike's slope height was 15 meter with the dike's

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materials in sand; and the soil layer beneath the dike (natural earth layer) was 8 m thick in soft clay. The length of the dike was 10 meter. In the first case and in order to consider the effect of the number of reinforcement layers, geotextile layers with equal lengths of 7 meter and variable vertical distances of 0.5, 0.6, 0.75 and 1 meter, were placed. The dike's slope angle was 1H:1.8V (61 degrees) in the first case. In the second case, in order to consider the effect of the dike's slope angle, geotextile layers of equal lengths of 7 m and equal vertical distances of 0.5 meter were placed. The dike's slope angle also was variable in this case, which was considered at 1H:1V (45 degrees), 1H:1.5V (56.3 degrees), 1H:1.8V (61 degrees) and 1H:3V (71.5 degrees). It is worthwhile to note that the dike being analyzed was subject to the effect of static loading (dike's weight). PLAXIS 8.5 software was used for modelling and the Mohr-Coulomb behavioral model was used for the intended materials.

PLAXIS is an advanced finite element software that has many applications for analyzing deformations and sustainability in geotechnics projects. In two-dimensional analyses, it is possible to choose two types of six-node and 15-node triangular elements. In the study presented in this paper, in order to achieve more accuracy in calculating stresses and strains, the 15-node elements were chosen. In six-node elements, the element displacement approximation function is considered of the second order; and the hardness matrix of this type of element is obtained by using three stress points. On the other hand, in triangular 15-node elements, the displacement approximation function is considered of the fourth order; and its stress points for determining the hardness matrix are considered as 12 points. Fig.1 shows the positions of the displacement points and stresses in these two types of elements (Brinkgreve and Vermeer 1998).

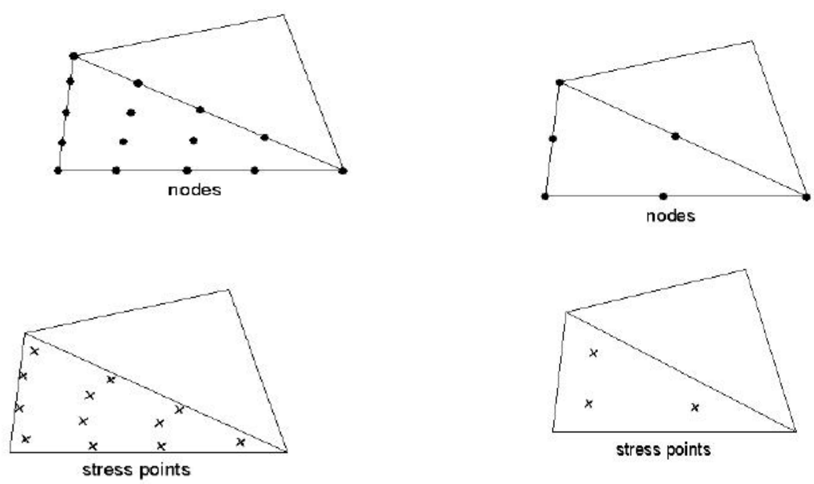
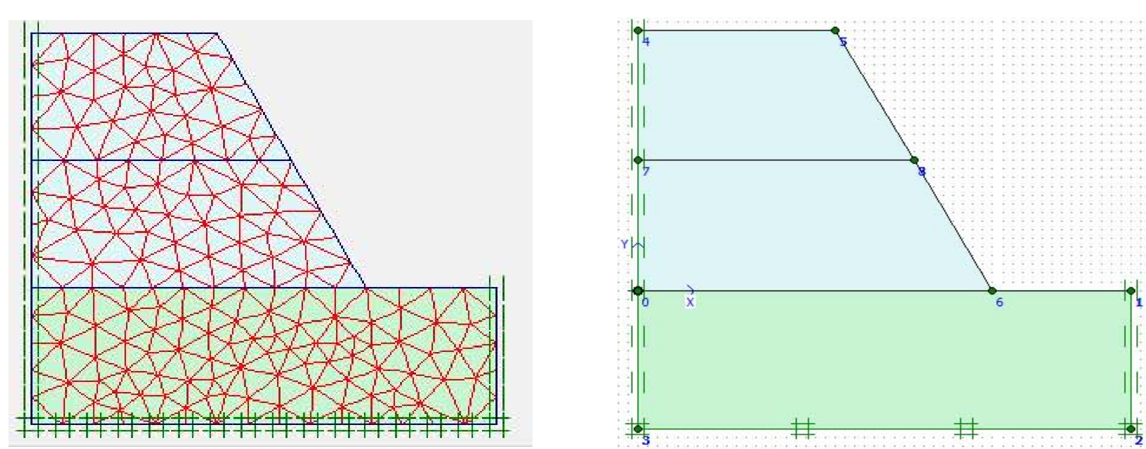


Fig. 1: Position of Nodes and Stress Points in Soil Elements

Also, in Figure 2, the geometry of the dike of interest and its netting are shown in the non-reinforced case.



(B) (A)

Fig. 2: A) Dike's Geometric Model; B) Dike's Netting

Table 1 describes the specifications of the dike in this study, which was reinforced by geotextiles and the soil layer beneath (natural earth layer).

Table 1: Specifications of Reinforced Dike and its Soil Layer Beneath.

Parameter	Name	sand	clay	unit
Model of material behaviour	Model	Mohr-Coulomb	Mohr-Coulomb	--
Type of material behaviour	Type	Drained	Drained	--
Soil unit weight above p.l.	γ_{wet}	17	15	KN/m^3
Soil unit weight below p.l.	γ_{sat}	21	18	KN/m^3
Horizental permeability	K_X	0.5	10^{-4}	m/day
Vertical permeability	K_y	0.5	10^{-4}	m/day
Young's modulus	E_{ref}	30000	3400	KN/m^2
Poisson's ratio	ν	0.3	0.33	--
Cohesion	C	1	5.5	KN/m^2
Friction angle	ϕ	34	24	degree
Dilatancy angle	Ψ	4	0	degree
Interface reduction factor	R_{inter}	0.8	--	--
Tensile stiffness of reinforcement	EA	1000	--	KN/m

Since the reinforcing material of the dike was a geotextile, it was necessary to specify the geotextile in PLAXIS, which then considers the geotextile as a tensile element and is represented as an EA parameter (axial stiffness) in the software. Note that this value is different for different types of geotextiles; therefore, in order to consider their effect on the safety factor, maximum total displacement, maximum horizontal displacement, maximum vertical displacement and maximum shear strain created in the dike, the geotextile tensile stiffness was set at 1000 KN/m. The underground water level was located at a depth of 8 m from the natural ground level (at the bottom of the clay layer).

III. Calculations and Analysis of Results

As previously mentioned, the objective of the presented study was to investigate the effect of the following parameters of the dike on the safety factor: the number of reinforcement layers, the dike's slope angle, the maximum total displacement, maximum horizontal displacement, maximum vertical displacement and maximum shear strain created in the dike. Each parameter is discussed below.

a) Effect of the Number of Reinforcement Layers

The numbers of reinforcement layers were set at 15 20, 25, and 30 in this experiment to determine this parameter's effect on the safety factor, the maximum total, horizontal, and vertical displacement and the maximum shear strain created in the dike when the tensile stiffness of the reinforcement layers was 1000 kN/m.

The type of netting on the reinforced dike when the number of reinforcement layers was15 as shown in Figure 3 and Figure 4 indicates the changes in the safety factor based on the number of reinforcement layers. It is obvious that when the number of reinforcement layers increased, the dike's safety factor increased. Also, it can be seen that when the number of reinforcement layers was 15, the safety factor was less than 1 and the dike was unstable. For the other quantities of reinforcement layers, the safety factor was always greater than 1 and the dike was stable. In fact, with an increase in the number of reinforcement layers, a probable sliding surface gradually moved away from the slope wall (i.e., as the number of reinforcement layers increased, the rigidity of the reinforced area increased).

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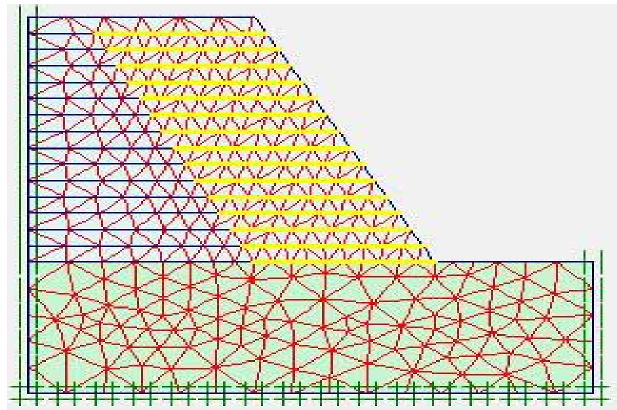

Fig. 3: Netting of the Reinforced Dike (the Number of Reinforcement Layers is 15)

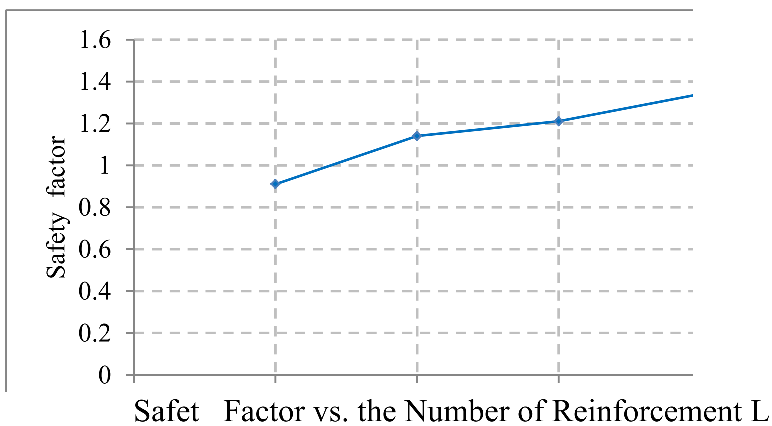

Fig. 4: Changes in Safety Factor vs. the Number of Reinforcement Layers

Also, Figure 5 shows that the extent of displacement decreased as the number of reinforcement layers increased. It can be seen that the maximum total displacement was more than the horizontal and vertical displacements and the maximum horizontal displacement was the least amount. In addition, when the number of reinforcement layers increased, the amount of tolerable stress in the dike increased and its deformation decreased. It is obvious from the figure that when the distance between the geotextiles decreased (an increase in layers), the maximum displacement decreased. Furthermore, when the number of layers was 15 (layers distance was1 m), the maximum displacement was large; but when the number of layers was 30 (layers distance was 50 cm), the maximum displacement decreased. This occurred because, in the case of relatively large distances between geotextiles, the stress between layers did not transmit well and the decrease in displacements (settlements) therefore was negligible compared to the case of small distances between layers. A 50 cm distance (the number of layers was 30), led to an ideal case of decreased displacement (settlement) in the dike because a lock was created between the soil particles as well as between the soil and the geotextile layers, which resulted in stress transmission from the upper to the lower layers, thereby greatly decreasing the dike's displacements.

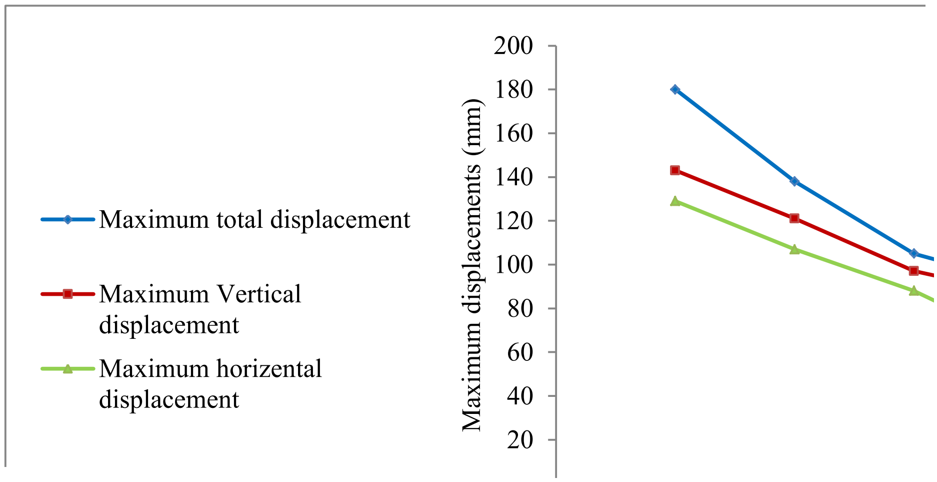

Fig. 5: Maximum Displacements Occurring in the Dike

Figure 6 shows the maximum shear strain caused in the dike vs. the number of reinforcement layers. It can be seen that when the number of reinforcement layers increased, the amount of maximum shear strain in the dike decreased. Also, the maximum shear strain caused in the dike occurred when the number of reinforcement layers was 15, and the least shear strain caused in the dike was when the number of layers was 30.

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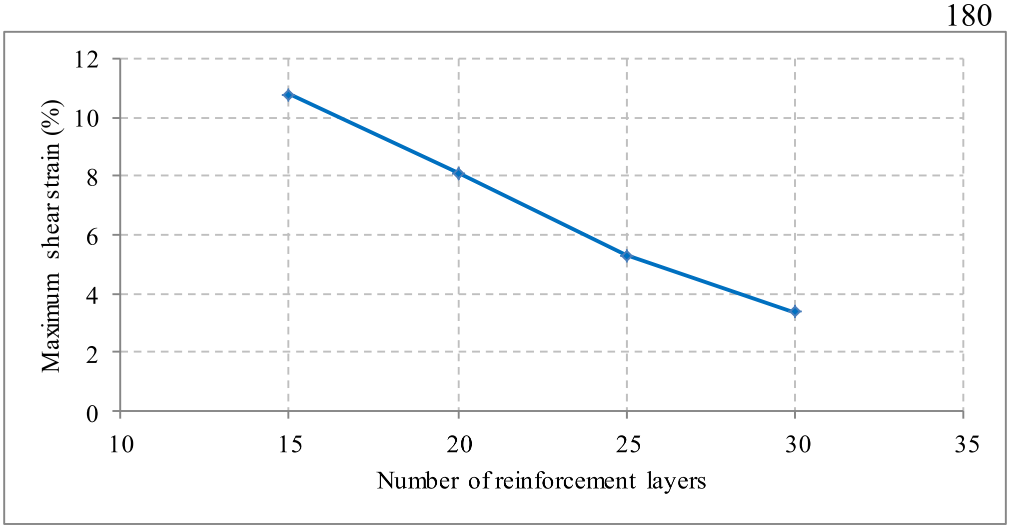

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Fig. 6: Maximum Shear Strain Occurring in the Dike

b) *Examining the Effect of the Dike's Slope Angle*

In this section, the effect of the dike's slope angle, which in this study were 45, 56.3, 61 and 71.5 degrees, on the safety factor, maximum final displacement, horizontal and vertical displacements, and maximum shear strain caused in the dike when the tensile hardness of the reinforcement layers was 1000 kN/m. Also, in Figure7, the type of netting for the reinforced dike when the slope angle was 45 degrees is shown. The changes in the safety factor vs. the dike's slope angle are shown in Figure 8. It can be seen that when the slope angle increased, the safety factor decreased. Also, when the dike's slope angle was 1H: 3V (71.5 degrees, the safety factor was less than 1 and the dike was unstable. In the other cases, the safety factor was greater than 1 and the dike was stable. In fact, it should be noted that the slope angle proved to be a very important parameter insofar as the extent of maximum tensile force caused in the reinforcement. layers; and the milder the slope was, the less the axial force created in the reinforcement.

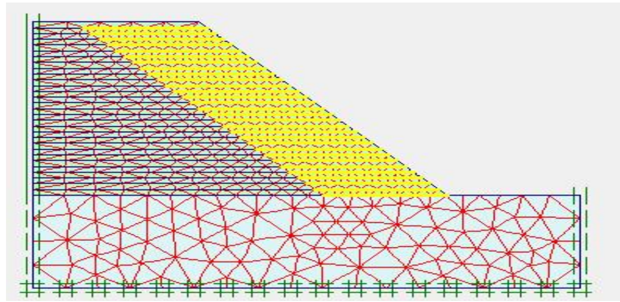

Fig. 7: Netting of the Reinforced Dike (Dike's Slope Angle is 45 Degrees)

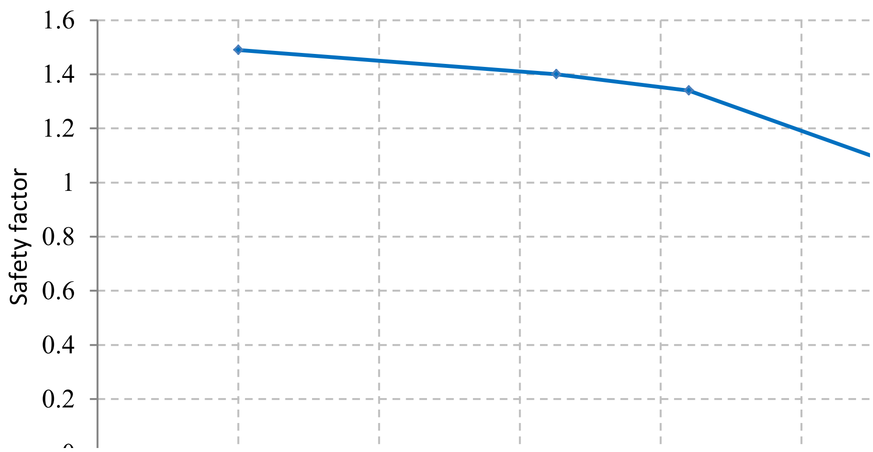

Fig. 8: Changes in Safety Factor vs. the Dike's Slope Angle

Figure 9 shows the maximum displacements created in the dike. It can be seen that when the dike's slope angle decreased, the maximum displacement created in the dike increased. Also, the least displacement of the dike was related to the maximum horizontal displacement; and when the dike's slope angle was 45 degrees, the least horizontal displacement was created. Moreover, since the maximum horizontal displacement commonly occurs at slope clevises, the milder the slope, the less the tuck of the soil was at clevises. A decrease in the dike's slope angle therefore had a greater effect on the maximum horizontal displacement of the dike.

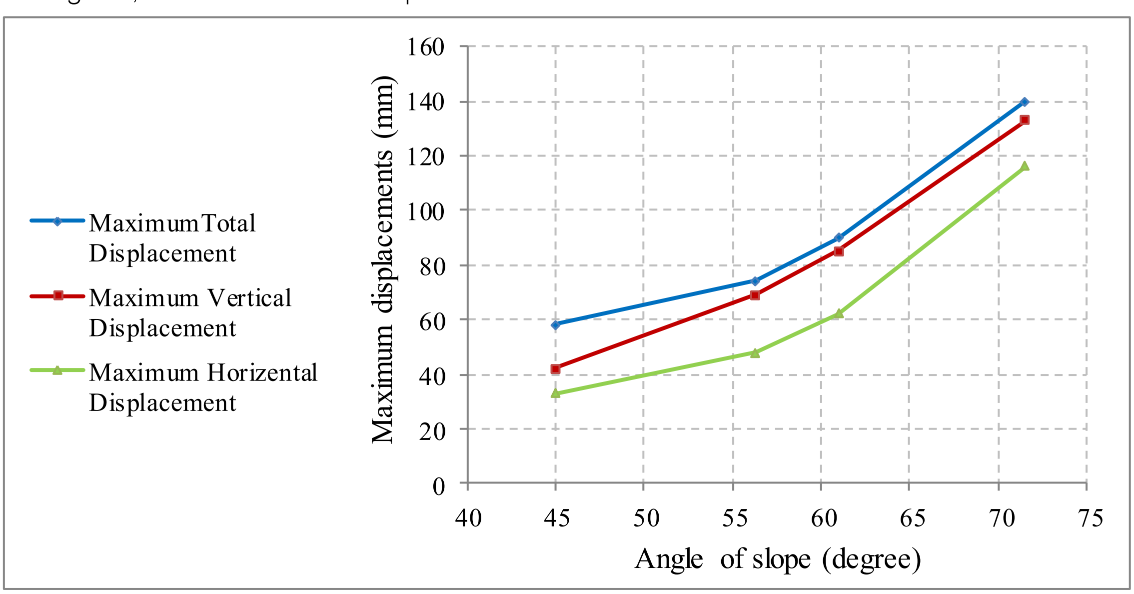

Fig. 9: Maximum Displacements Created in the Dike

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Figure10 shows the maximum shear strain caused in the dike vs. the dike's slope angle. It is easily seen that when the dike's slope angle decreased, the maximum shear strain created in the dike increased. Also, the least shear strain occurred when the dike's slope angle was 45 degrees, and the maximum shear strain occurred when the slope angle was 71.5 degrees.

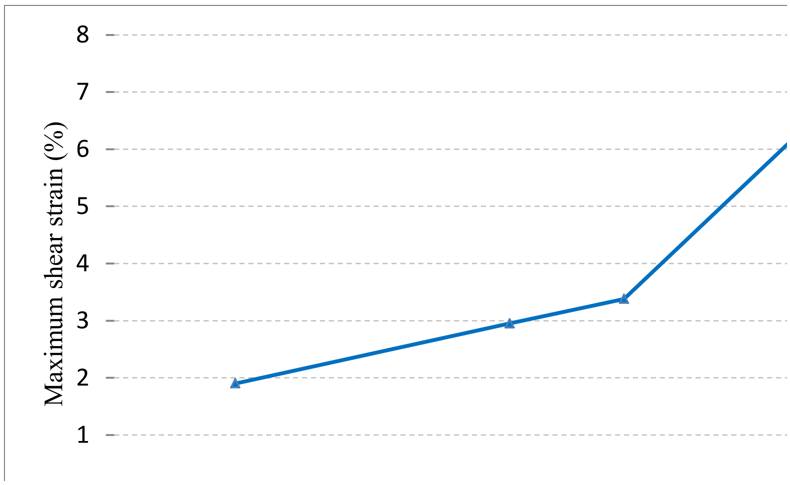

Fig. 10: Maximum Shear Strain Created in the Dike

IV. Conclusions

The conclusions of the study presented in this paper can be are summarized as follows:

1. Using geotextile layers can lead to improvement in a dike's performance; and more specifically, a dike reinforced by geotextiles has less slide and settlement than a dike without geotextile reinforcement.
2. With an increase in the number of reinforcement layers, the safety factor of a dike against slides increases insofar as the maximum total and the horizontal and vertical displacements, and the maximum shear strain created in the dike decreases.
3. With an increase in the number of reinforcement layers, a probable sliding surface gradually moves away from a slope wall and the rigidity of the reinforced area increases.
4. With an increase in a dike's slope angle, the dike's safety factor against a slide decreases; and the maximum total and the horizontal and vertical displacements as well as the maximum shear strain created in the dike increase.
5. The optimal case for the dike in this study occurred when the number of reinforcement layers was 30 and the dike's slope angle was 45 degrees.

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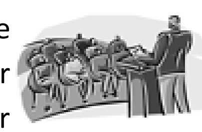

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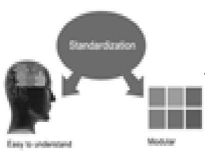

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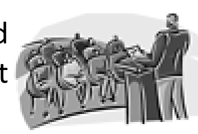

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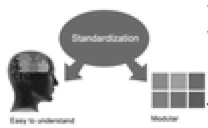

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Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

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Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

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(Free of charge) from the following website:

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TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

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7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

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9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
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This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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