bearing, tuned mass damper, etc. Earthquake resistant construction techniques are as important as quality control and using correct materials. The result structure need not be strong but just able to withstand seismic vibration of considerable measure while sustaining acceptable damage.

Base isolation is one of the most efficient method used in protecting a structure against earthquakes. It is a collection of structural elements which should substantially decouple a superstructure from its substructure resting on a shaking ground, thus protecting the building. Rubber bearings are used as isolators to lift or separate the building from the ground, which would also sustain the load of the building and restore the building to its original position after the quake. Dampers are used to absorb some of the shock, protecting the structure from a sudden jilt in case of extreme earthquakes while they completely absorb the regular minor seismic shocks. It can be used in all type of structures, but only in hard soil and not soft. Lead rubber bearings are a type of base isolation method, which uses heavy damping. Other types of base isolators include simple roller bearing, springs with damp base isolation. Adaptive base isolator uses tunable isolator which adjust its properties based on the inputs such that minimum vibration energy is transferred. Magnetorheological fluid dampers and isolators with Magnetorheological elastomer have been suggested as adaptive base isolators.

Viscoelastic dampers are another type of dampers that are used in structures to control their vibrations during an earthquake. They are materials which possess the properties of both a viscous material, which resists the motion and of an elastic body, which has a tendency to return to its original position. These two properties combined offer reliable seismic protection.
Hysteretic dampers provide seismic reliability in structures using the seismic input energy dissipation.

Forensic structural engineering is another field which plays an important role in disaster control and prevention. It takes the principle of learning from our mistakes in the field of civil engineering. It involves the study of a collapsed or failed building and the design of new structures without the faults or with means to overcome them. It deals with the retracing of processes that lead to the failure and locating the cause. In India, it is still a much underrated field and lacks in research prospects.

2) Floods

India is one of the most flood prone countries in the world, with an average annual rainfall of 1150mm, which varies drastically from region to region, with the Khasi Hills, Western Ghats and most of the Brahmaputra Valley receiving over 2500mm. Twenty three out of the thirty three states and union territories are subjected to this calamity, which is 40 million hectares of land, roughly about one eighth of the country's geographical area. [7] Monsoons, highly silted river systems and the steep and highly erodible mountains are its main causes.

In the monsoon of 2004, the city of Mumbai came to a complete halt due to a rainfall of 944mm in the course of 24 hours with hourly rainfall exceeding 190m/hr. This took the lives of 447 people and effected the commercial, industrial and trading activities for 3 days. The severity of the situation was caused due to over urbanization of the city, poor planning and failure of the drainage system.

In the report by the Ministry of Home Affairs, regarding Disaster Management in India, 2011, it is stated that, "Though non-structural measures improve the preparedness in floods and reduce the losses, the necessity of structural measures would always remain to reduce the extent of physical damage caused by floods."

Structures such as dams' i.e., debris dam, multi-purpose dams and check dams, retaining walls, bunding, sausage groynes, gabion/mattress groynes, paved drains, reservoirs are constructed for flood control purposes after proper surveying of the area is complete to attain data such as floodplains elevation, general topography, geological rock distribution, etc.

Dams are used to retain water, it controls the rate of flow and the reservoirs of the dams suppress water and provides it for various economical activities. Check dams are smaller dams, they are usually constructed is a series, with the spacing between two consequent dams being such that the toe of the upstream dam being equal to the elevation of the downstream dam's crest. The main purpose of these dams are to prevent erosion of the soil from runoff water. Due to its small size, constructing them is comparatively simpler, without the use of much technologies and also doesn't cause the change in the rivers course thus ecology of the area is not drastically effected. But this also means that it cannot be used in steeper slopes where the velocity will be much higher, shortening the distance between the subsequent dams. This is the reason why floods of rivers such as the Brahmaputra cannot be controlled by them.

Bundings are commonly used to protect the environment from chemical spills but are also used in flood control measures since it can prevent soil erosion and protect small areas from flooding. But fails in bigger scenarios such as in the case of the Brahmaputra flooding but it is being used by the Karnataka Government to increase groundwater levels. It is mainly a flexible structure made of galvanized wire mesh, stones, wild canes and riverbed materials.

The most direct structure built for flood control is perhaps a reservoir. It stores the flood waters and later distributes it in other areas for other purposes. Retaining walls are concrete block structures which controls flood damage by protecting the foundations of the area from being flown along by the water. Floodways are a means of diverting the flood waters to a topographically lower region or to another bigger water body.

Sausage groynes are long cylindrical structures which are placed along the bank of the slopes of streams to help improve the slope stability. Gabion/Mattress Groynes are used in the faster moving streams, where erosion is occurring at a faster rate. They trap soil particles to allow a build-up of soil, thus encouraging the growth of vegetation.

Paved drains are used to remove water from areas which are highly susceptible to erosion such as road sides, under bridges and steep slopes. In cities and urbanized areas, structures such as levees and flood walls help to confined and control the flood waters.

Channel alternatives, where meanders are cut to deepen and widen the channel, and detention ponds, which reduce peak flows are other civil engineering structures which contribute to flood control measure.

3) Landslides

It has been estimated that 30% of the world's landslides occur in the Himalayas. Landslides are a major natural disaster in the country, with a rough estimate of monetary loss of the order of 100crore to 150crore per annum. [2] Although the major driving force in a landslide is gravity, human activities including construction may act as the trigger.

In the summer of 2004, in Yellowstone National Park, excavation into a slope for a road construction, resulted in flattening the area at the base of the slope, causing the removal of the basal support which led to slope failure thus a landslide. An estimated 30-thousand tons of earthen material flowed onto a three quarter mile long section of road. The slide went up to 10 feet deep and 90 yards long. This illustrates the crucial role played by the toe of the slope in its stability. Proper study and surveying of the soil before construction works would have avoided such a situation.

Blasting, vibrations from machinery or traffic, construction imposes new load on the slope and alters the shape of the slope. Surface mapping, ground profiling, monitoring ground movements, numerical modelling and stability analyses for slopes, hazard assessments are few ways in which geotechnical engineering can prevent landslides. Principles of Hydraulic engineering can be adapted to divert rainwater or snowfall so that it doesn't damage the natural draining system in the slope. Artificial drainage channels can be made, so that it transfers the water where it is not detrimental to the stability of the slope. Geometry of the slope can be altered to prevent instability from seismic activity, even gravity can be dealt with by vegetating the slope. In cases of construction on the top of the slopes, a proper safety setback distance should be maintained between the top of the slope and the edge.

3.3 Techniques Developed

1) Nanotechnology and MEM's

Heath of a structure is very crucial in determining the way it will act during a natural disaster, it effects the economy of the country and the lifestyles of the people. The challenge faced by engineers is to maintain the security and safety of large civil infrastructures such as bridges, dams, skyscrapers, nuclear power plants during the event of a natural disaster or a terrorist attack. Until recently, the main obstacle was the lack of sensors which would be easy to install, economical, and be harsh environment resistant. Recent developments in the fields of nanotechnology and MEMs (micro-electro mechanical system) have proved to provide an innovative solution. These have led to wireless, inexpensive, compact, high density data collection systems. Systems working with these concepts have been able to provide real time condition assessment of structures, and assess their integrity after attacks. It also provides identification of incipient damage in structures experiencing long term deterioration. Till date, systems based on nanotechnology and MEMs-based systems have been able to wirelessly detect and monitor different damage mechanisms in concrete structures and monitor critical structures' stability during floods and barge impact.

2) Hydraulic Modelling System

Hydrologic Modelling System (HEC-HMS) is a software developed to simulate the precipitation runoff processes of dendritic watershed systems. The program has a graphical user interface which makes the study of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation user friendly. Supplemental analysis tools are provided for parameter estimation, depth-area analysis, flow forecasting, erosion and sediment transport, and nutrient water quality. This system was successfully used in the Damodar Basin in eastern India.

4. Case Study-Flooding of the Brahmaputra

The Brahmaputra also referred to as Tsangpo-Brahmaputra is a major river in Asia. It originates in the Angsi Glacier in the Northern Himalayas of Tibet, flows through Southern Tibet to enter India between deep gorges in Arunachal Pradesh. It flows into Assam and then exits the country into Bangladesh where it finally empties into the Bay of Bengal. The river is 2,900 km long, and as deep as 38m in places. It is a classic example of a braided river and thus when the Himalayan snow melts or during the monsoons, it causes catastrophic flooding.

In Assam, the flood plain is 80-100km wide and 1000km long. The river itself can get as wide as 10km. Its average discharge is 19,000m3/sec which goes up to 100,000m3/sec during the flooding season, which is generally the months of June to October. Floods in Assam are characterized by their extremely large magnitude, high frequency and extensive devastation. This natural hazard repeats itself year after year and not only costs lives but also leaves the economy of the state, which is largely agricultural, in utter shambles. Having said this, it is also important to point out that periodic flooding is an important phenomenon for the sustainability of the Brahmaputra Valley Ecosystem, since it helps maintain the lowland grasslands and associated wildlife, also depositing fresh aluminum thus replenishing the fertile soil of the valley.

Statistics of the floods in Assam are alarming. In 2013, 12 out of 27 districts were affected-100,000 people and 396 villages. 7,000 hectares of agricultural land was destroyed. The 2012 floods displaced over 1.2 million. 2,500 hectares of land gets eroded on an average by the river. The floods have been an annual feature and nothing new, with references to disastrous floods in the past including the one in 1950, when half the town of Dibrugarh was washed away.

Flooding is caused by the inability of the catchments areas to contain the capacity of the flow which increases during heavy rainfall. The Brahmaputra's catchment area receives 110cm-635cm of rainfall annually thus floods are frequent and severe. Moreover, the rocks of the surrounding hills are prone to excessive erosion, causing high slit charge in the river. Excessive deforestation in the upstream and downstream areas of the river has also caused siltation, resulting in the abnormal rise in the river beds. The unfortunate geotechnical positioning of the river is another factor which cannot be overlooked. As mentioned earlier, Assam falls in Seismic Zone 5, and frequent earthquakes cause landslides which upset the river's stability.

A Brahmaputra Board was set up by the Government in 1981, whose main objective was to come up with a master plan to control the floods and bank erosion and improve the drainage in the Brahmaputra and Barak Valley. Plans have been devised but even after almost half a century of flood situations and control measures, the fury of the river remains largely undiminished.

The most popular flood control measure perhaps undertaken by the Government was construction of 4000km of earth embankments along the river, which by now have outlived their design life. Embankments are small walls to restrain flood waters. Though efficient and easy to build, they require a lot of maintenance which requires high funding and are very susceptible to erosion. They also tend to prevent the slit from the river from entering the floodplains, which will be a matter of concern for an economy dependent on the fertility of the land. Cases of breaching are common in the State, causing widespread devastation. In 2013, victims claimed there were no embankments at various places and that those breached by previous floods weren't repaired. But if proper care is taken, the results are very awarding. The embankments in the Kosi River are an example of their success. Permanent roads, railways thus better trade, commerce and communication, also a better standard of living were achieved from controlling the flood waters.

Multi-purpose dams don't contribute much to flood control. Such huge dams are also a big threat. The seismicity of the area doesn't guarantee the dam's stability. In case of war, dams become very vulnerable and with the Chinese waiting at the Northeastern border, should such a situation arise, bombing of the dams will itself win the war for the Chinese. The risks outweighs the benefits for huge flood control dams, 26 million people shouldn't be sitting ducks in case of a failure.

Check dams may be a solution opposed to the huge dams but in a river like the Brahmaputra, with its high velocity and steep gradient, check dams are impractical since their intervals will have to be too small for efficiency.

Another, non-structural flood control measure will be flood plain management. This requires excessive knowledge of the topography of the land which can be achieved by surveying and developing contour maps. Areas should be restricted and some should be protected or put on alert. People inhabiting the areas should be made well aware of do's and don'ts. The wide-ranging surveying required and ordered by the Center was not undertaken stating the lack of funds and the lack of means but with the current technologies available such as remote sensing, the situation can be improved.

The situation in Assam and the Brahmaputra is very unique. The Himalayas in the northern part of the country do not face similar problems mainly because of their deep, narrow valleys as opposed to the plain and the wide in Assam. It is easier to construct dams, and other structural flood control measures.

5. Proposed Solution

The flooding is accentuated by erosion and silting of the river bed, resulting in decrease of the carrying capacity. If the focus is shifted to increasing the capacity, the floods may be controlled.

The capacity of the river can be increased either by dredging or by widening the width of the river. Widening of the river will involve the increase in the width of the river at certain places. The river width needs to be decided according to the design flood discharge, considering the gradient, topographic features of the river and the situations of land use from the upstream to the downstream of the river, etc. It depends on the conditions of land acquisition, housing congestions as well. This can be achieved either by mechanical means or by self-dynamic means which though time consuming are gentler on the ecology of the area. Also care needs to be taken that widening is done without changing the longitudinal profile of the river. Revetments can be employed to ensure slope stability and better protection against erosion along with absorbing the energy of the water currents. Increasing the width will also increase the velocity of the flow, which will allow flood waters to be removed more quickly and also aid in navigation. Channel alteration is another possibility, by changing the natural alignment of the river, by straitening it, but this will increase the possibility of flooding downstream since water will get carried down faster.

Dredging is the process of increasing the river depth by removing unnatural particles from the river bed along with excessive slit. It can be done either by heavy industrial pumps and diggers or by dislodging sediments that then encourages the natural flow of the river to transport it. This increases the cross sectional area of the river thus the water holding capacity of the river rises and its hydraulic efficiency. The longitudinal profile needs to be considered while the process, average elevation and not the deepest elevation should be taken as the desired level. Also too much deepening will threaten the ground water levels. The dredged material should not be neglected and plans for its disposal need to be made; they can be used to fill in the low lying areas or to build houses on higher grounds.

Although the width is much easier to adjust than the depth, in the case of the Brahmaputra dredging is a more favorable option due to the densely populated banks. Procedures such as containment can be used in such situations but the procedure is highly complex. It is an extreme form of channelization where sub-surface tunnels are built which contains the river water. But they require high maintenance. It needs to be ensured that there are no blockages which will make the flood situation worse. Other than its complexities, this is a smart way of using the available area for dual purposes, while ensuring flood safety.

None of these techniques have been seriously undertaken by the Assam Government at any point, this may be due to the very high capital funding that is required or the possible ecological impact or the fact that this is possible only in small portions, but factors are continuing to rise the river bed and exacerbate flooding around the banks.

6. Conclusion

The paper presented how civil engineering and disaster management are in fact very dependent topics. Structurally sound structures play a crucial role in the safety of the people during a disaster.

India is a disaster prone country with different disasters prone to different areas depending on the topography. The Northern Plains are prone to earthquakes and floods, while the coast is prone to cyclones, and the Western Ghats to frequent landslides. The country loses about 2% of its GDP on an average to disasters. Their management is a very crucial topic and civil engineering with all its different fields be it geotechnical or structural or hydraulic engineering has a vital role to play in it.

The type and the extend of the damage to the structure during an earthquake depends on the strength of the materials, the types and the quality used for construction, joint details, foundation stability, etc. besides the intensity of the earthquake shock. Methods such as base isolation method, lead rubber bearings, tuned mass dampers used in buildings in areas of high seismicity for their seismic strengthening have been studied upon. Different types of dampers are used in the process. Earthquake engineering which focuses on constructing sound buildings to withstand earthquakes is gaining more and more importance as an independent field of research. Also the study of the land is very crucial, the soil underneath, and possible drainage patterns.
Floods are perhaps the most common natural disaster in the country. Development of flood control structures such as different types of dams, groynes, and bundings can only save the crores of rupees that is annually lost because of them.

The Himalayas face 30% of the world's landslides, and the topography of the land needs to be properly studied upon to prevent them. Geotechnical Engineering comes in here to understand the slope, identify its toe, for surface mapping, and ground profiling, monitoring ground movements, numerical modelling and stability analyses for slopes, hazard assessments. The role of hydraulic engineers is to divert rainwaters and study the land for possible artificial drainage channels.

New developments in technology further assists civil engineers to play their role in disaster management. MEM's and nanotechnology assists by providing a real time health analysis of a structure and the HEC-HMS software provides an easy interface to understand the drainage area of a river basin, its water availability, flooding possibilities, etc.

The case study presented signifies the problem that the Brahmaputra still continues to flood annually. After years of investing in flood control measures, little improvement has been achieved. People are still getting displaced by the thousands and villages still affected by the hundreds. Even after ground breaking discoveries in river management technologies, the situation in Assam is not under control. Corruption may be the main reason for the poor condition but the case of the Brahmaputra is also very unique. Nowhere is such a mighty river, so prone to flooding having to face similar conditions of high seismicity and high alert as a potential target for an enemy state.

Dams have a high risk factor and other options such as embankments are too weak to contain the river. Channelization, an attempt to change the natural geometry of the river, may be the only possible solution. By widening the width or deepening the river, water holding capacity of the river increases thus floods can be controlled. This requires a significant amount of capital and is a very time consuming measure but since almost half a decade of control measures have failed, and since it hits the state's economy so hard, it is a very good future investment. Its impact on the ecology of the area is still being studied upon.
If the flood situation in Assam is brought under control, with the fertility of the land, it can develop up to its full potential. Better roads, better standard of living, better security is possible only after the Brahmaputra is tamed.

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