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Evacuation System for a Rural Coast of Tamil Nadu

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***Abstract* - The experience gained by the vulnerabilities of the Indian Ocean Tsunami of 2004 and Pacific Ocean Tsunami of 2011 along with other seasonal monsoon hazards have motivated the entire globe for a level of multi hazard mitigation. Coastal reconstruction, warning systems, community awareness and participation and institutional involvement have become challenging. With all interpretations, if there is a missing strategy identified, it is evidently the evacuation system in the rural coast of Tamil Nadu state of India. The cyclone relief shelters and even the recent Tsunami relief shelters are not adequate for the magnitude of the problems. Particularly, vertical evacuation system has been the need of the hour. In this paper, the requirements of vertical evacuation system is explained and the opt use of 4D visualisation model for the exploration of the problem that may often arise with the existing means of such construction planning for the typical coastal zone and perspective requirements for the 4D applications to support practical use on site management have been highlighted with a construction model.**

INTRODUCTION

Massive damage to the ecological environment like fire destroying forests, coastal storms moving barrier islands, earthquake altering the landscape and Tsunami devastating the coast has become a part of the natural system. The term disaster is used when a community is affected by a hazard usually defined as an event that overwhelms that community's capacity to cope. In other words, the impact of the disaster is determined by the extent of a community's vulnerability to the hazard which is not natural. It is the human dimension of disasters, the result of the whole range of economic, social, cultural, political factors of local, regional, national, international factors that shape the life of people and create the environment in which they have been living. Research, infrastructure changes, warning systems, emergency preparedness and public education on awareness, if taken seriously and generously supported, could transform all natural hazards into natural wonders. But, the growth trends in coastal areas have the obvious consequences of increasing human exposure to disasters.

Two-thirds of the world's population lives in the close proximity to coastline and likely 10% in the vulnerable areas (U.S. Report, 1998). Their role as primary centers for commercial fishing, transportation, aqua culture, and tourism/recreation has remained the coast, a crucial segment of the overall economy. In the same trend, the scientists have given a threat of sea level rise. The Intergovernmental Panel on Climate Change (IPCC) reported in 2007 that the sea level could rise by up to 59cm in this century. But the opinion of many scientists is that the changes in the polar ice sheets could raise sea levels by a meter or more by 2100 and warning is given that the implications could be severe. The situation is still worse in the rural areas of the developing countries like India. Keeping in mind all these future disasters as an adding complex nature of the coastal zone, a disaster reduction programme is a must for mitigation. A Multi-hazard mitigation should consist of sustained actions taken to permanently eliminate or reduce risks for long-term. Because of the attractiveness of coast and the long gaps between Tsunami events, the coastal communities continued for development activities.

The Scenario

India has been traditionally vulnerable to disasters by its unique geo-climatic conditions. Seasonal floods, droughts, cyclones, earthquakes and landslides have been a recurrent phenomenon. After the World War, the next tragedy in the history was the Indian Ocean Tsunami of 2004 that affected fourteen countries of two continents. Further, the 2011 Tsunami of Pacific Ocean has made the record of multiple disasters initiated by ocean earthquake followed by Tsunami and fire accidents. Apart from other reasons, the settlement along the coastal line in the near vicinity of the coast is realized to be at danger.

Tamil Nadu is the eleventh largest state covering a coastline of about 1000 km in the east falling in low seismic hazard zone. As observed, the vulnerability of the problem is totally typical that, the location of the main habitation of fishing communities is within 100-200m of the coast. Chennai (Madras) topper for Tourism lies in the second place for portal activities, and fifth for Industrial activities among the Indian cities (Rahul Goswami, 2009). Coast between Chennai and Kanniyakumari is occupied by various geomorphic features: beach ridges, swales, sand dunes, deltaic plain, palaeo- tidal flats, palaeo lagoons, salt marshes, palaeo channels (Sundar and Sundaravadivelu, 2005). The mangrove forest of Pichavaram offering a bio shield is a famous tourist center along the east coast. Historically important places like Portonovo, Nagapattinam and Velankanni are also along the coast. All these were highly disturbed by the December 2004 Tsunami. In

Portonovo, A Centre for Advanced Studies in Marine Biology (established in 1956 by Annamalai University) has been offering good service through Coastal information system.

The coastal zone of Cuddalore, Villupuram and Nagapattinam districts of the Tamil Nadu is experiencing threat from many disasters such as storm, cyclone, flood, erosion and tsunami (Mahendra et al., 2011). These were the worst affected area during the yearly cyclones of east coast (Nisha, Super, Thane, Neelam, Lehar, Roanu, etc.). As per the multi-hazard vulnerability maps prepared, 3.46 million inhabitants of 129 villages (360 sq.km area) were threatened by this assessment. In general, river systems act as the flooding corridors which carry larger and longer hinterland inundation. However, the ill effect of 2004 Tsunami was predominant.

Coastal Disaster Resistant Structures

Prabhakar, et al. (2011) give some critical review of civil engineering aspects to be adopted with tsunami's effects and the combination of earthquakes and tsunamis. It also gives facts about characteristics of tsunami induced waves. Andhra Pradesh government has decided to construct 1230 dwelling units in the proposed tsunami-resistant housing colonies for fishermen in the coastal villages of Vizianagaram district. Soil investigations were carried out in the proposed sites and recommendations/guidelines were given for better tsunami resistant building and discussed. Ankush Agarwal, (2007) has illustrated the architecture, damaging effects of cyclones, site selection, and design of cyclone resistant structures for Indian Coastal line. The failure components and catastrophic failures of different types of houses are also explained in detail for cyclone prone coastal area. It was accepted by the humanitarian community that the issue on tsunami design should be addressed and that new houses should be tsunami proofing where, previously there was none (Regan, 2006). Ioan Nistor et al (2010) have made a comprehensive research program on tsunami-induced forces on infrastructure located in coastal areas (spanned between 2005 and 2010) which included several field data reconnaissance missions, analytical, experimental and numerical modeling of the extreme hydrodynamic forces on buildings and their component structural elements used to develop design guidelines.

Challenges and Risks

Japan, where tsunami science and response measures first began following a disaster in 1896, has produced countermeasures and response plans. Many tsunami walls were built against the expected Tsunamis. The tsunami which struck Okushiri Island of Hokkaidō within 5 minutes of the Earthquake on 12th July, 1993 created 30m tall waves and it did not prevent major destruction and loss of life. Therefore a lifelong safe sea wall is a challenging task. Janakarajan (2009) examined the challenges of climate change impacts and disaster risk reduction strategies in Tamil Nadu. Research and Analytical process are made by initial secondary data collection from various governmental and non-governmental sources, ranking potential costs and benefits of strategies to reduce risks as perceived by communities. Though the Tamil Nadu Government has distinguished itself for excellent disaster management, good governance in a post disaster situation is inadequate and cannot overcome all the chronic problems that existed prior to the disaster (NCRC Report, 2005). Information systems and proper data bases have to be in place to ensure that all operations in the post disaster situation are properly planned and executed. Apart from all these, there is an urgent need to provide evacuation systems in all occasions of disasters.

Evacuation Techniques

There are two types of evacuation techniques namely, horizontal and vertical evacuation. The strategy of evacuating people to places far from the tsunami zone is known as horizontal evacuation. A vertical evacuation structure is a building or earthen mound that has sufficient height to elevate evacuees above the level of tsunami inundation, and is designed and constructed with the strength and resiliency needed to resist the effects of tsunami waves.

Tsunami evacuation buildings (TEBs) can be an important element to insuring that schools, essential facilities, and government buildings are able to meet their everyday purposes, and continue to function after the earthquake and tsunami (Jay Raskin, et al. 2009). In addition, many of the tourists are attracted to visit the beaches, which are high risk areas as in Japan. The guidelines of FEMA P646 are taken for the design of structures for vertical evacuation from Tsunamis. Preliminary design, technical and social issues are considered, including tsunami dissipater to deflect wave energy away from the TEB and geotechnical and structural design to survive a magnitude 9 EQ and near field tsunami. Conceptual design concepts for the future TEB shall be developed for effective evacuation. Vertical evacuation structure should be an engineered reinforced concrete or steel framed or composite structure. Impact forces and damming effects from water-borne debris, uplift forces, and hydrodynamic forces on the floor slab must be considered and primarily for the scour around the foundations. To provide refuge from tsunami inundation, vertical evacuation solutions must have the capacity to receive a good number of people in short time frame and efficiently transport them from flooding. Vertical evacuation facilities can be single-purpose, multi-purpose, or multi-hazard facilities.

Evacuation System for Tamil Nadu Coast

The available time to evacuate depends on the distance from the source and on the efficiency of the early warning system. The conventional cyclone relief shelter provided to safeguard people from cyclones and floods is at 1-2km from coast line. It is a two storied building circular in plan. These occasionally used buildings have served during floods and cyclones but, only for a period ranging from 8-10 years. The low level construction, exposed rebars, cracking in columns and walls and spalling of concrete, made the people not to use them effectively. But the disaster relief buildings constructed after 2004 Tsunami provides better utility (figure 1). The ground floor is left free for utility in making repair works or for marketing. Also during high tides and tsunami, the waves can pass through and recede, safely keeping the people in the first and second floors. However, the capacity of such buildings constructed at various places and number of units are not adequate. Therefore, the present trend setup is to make a better evacuation system. The usual practice in mitigating against Tsunami after the December 2004 Indian Ocean Tsunami in countries and in particular after March 2011 Tsunami of Pacific ocean is to provide Coastal Disaster Resistant Structures and vertical evacuation system (figure 2).

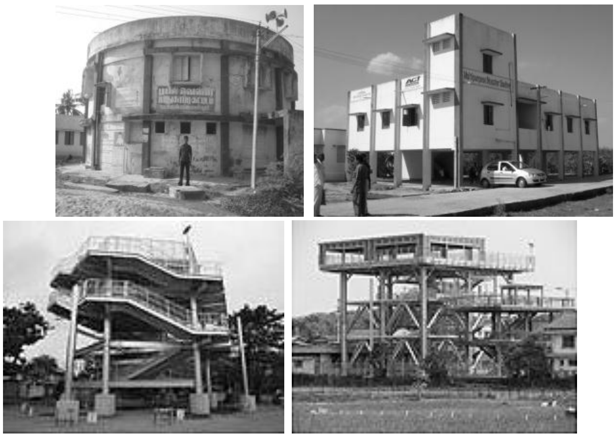

Fig.2. Vertical evacuation in Japan

Problem with implementation

During the construction of post-Tsunami rehabilitation structures, individual group houses at various locations where planned and there existed shortage and poor transport of construction materials and lack of skilled workers due to the massive construction activities in emergency situation. As a result, there was a delay in handing over the houses to the beneficiaries in time. Therefore, in the implementation of coastal developmental projects like construction of many multistoried vertical evacuation structures simultaneously, the 4D visualisation model is used.

4D Visualisation

Construction industries have a feeling that coastal construction activities involve many additional factors like coastal regulations, land use planning, scarcity of building materials, escalation of material and labor cost, need of innovative methodologies and more voluminous of construction projects. Traditional construction planning tools do not represent and communicate the spatial and temporal, or four-dimensional aspect of construction schedule effectively. A strong need still exists for comprehensive tools which allow architects, engineers and contractors, to simulate and visualize construction sequences as part of an interacting experience. The 4D-CAD model provide the basis for a common language between all parties and a representation of the schedule itself. Design and construction planning alternatively can be assessed realistically within the context of space and time. Simultaneously, modeling both the temporal and spatial aspects of construction intent can optimize and justify the decision involved in the planning and design of project. It is therefore felt that construction planning with control system using 4D visualization can help the planers as well as the construction industries to satisfy the needs.

Four dimensional (4D) models are developed in three steps namely,

Step 1: development of a 3D model,
Step 2: development of a construction time plan and
Step 3: interfacing 4D visualization (by linking steps 1and 2).

The 4D site management model links a 3D model of construction project with a project activity schedule, each activity suitably annotated with its resource requirements including material, plan and workspace. It not only realised that 3D visualization of construction site and construction process of multi-storey building, but also automatically optimize and controls the whole construction planning, and helps project managers, layout plans, storage areas and other facilities in the construction site. Through linking the 3D model with construction activity schedule, the 4D site management model for a project can be automatically generated and the site managers can dynamically plan temporary facilities on layout and control the use of site space according to construction schedule or real construction progress and relevant resource requirement. Finally the time –space-quantity relationship of construction site is created by some linking rules (Visual Basic). The simulation represents a view through time and three-dimensional space to give visualisation of the planned construction. The Organization of the 4D intelligent site management model is shown in figure 3.

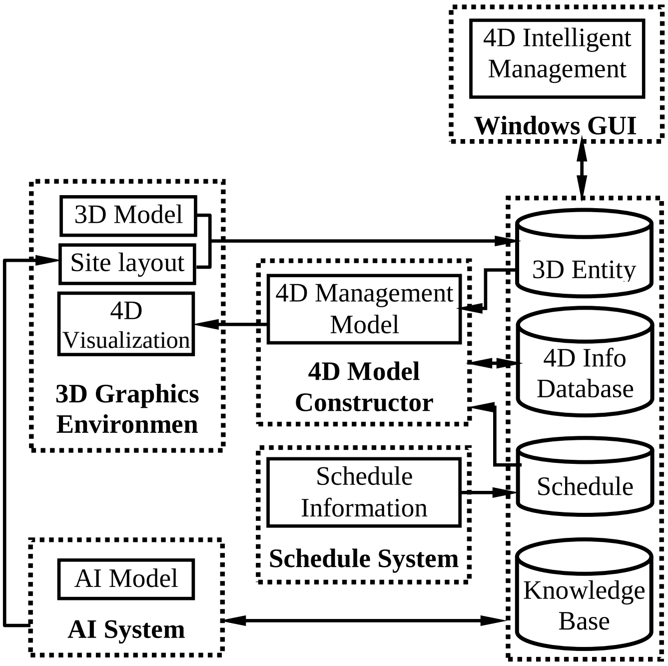

Fig.3 Organization of the 4D intelligent site management model

The concept of 4D models that incorporates the time dimension into the 3D visualization has become the focus of much research work.

3D model + Time = 4D model
3D model (AutoCAD) + Time Schedule (Microsoft Project) = 4D model

There are three basic object types used in creating a 3D model that consist of wire frame, surface, and solid objects. A wire frame object is defined by a series of points, lines and curves with no true mass or volume. Surface, models are created from wire frame objects whose surfaces are displayed as meshes or planer facets. The solid model is the most useful in creating 3D building models. A wire frame of the model of a 17 storied structure and the final view are shown in figure 4 and the visual representation of the sequence of construction (4D Model) is shown as figure 5.

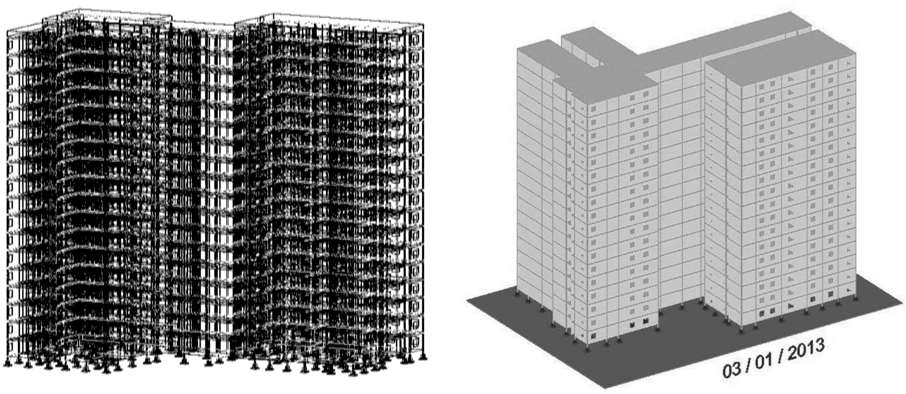

Fig. 4 Wire frame model and the final view

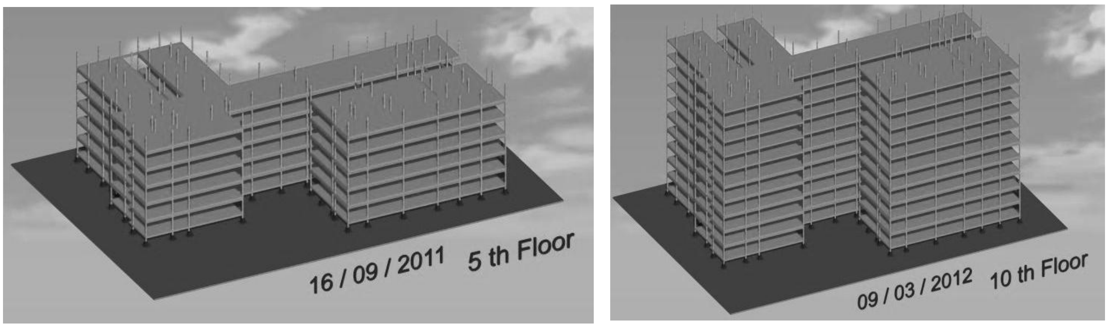

Fig. 5 Visual Representation of the Sequence of Construction

CONCLUSION

More possibilities are there for large scale EQs to occur and generate tsunamis as a major threat to sustainable development in addition to the seasonal monsoon hazards in coastal areas. Even with a sophisticated warning system that can detect an EQ in seconds and provide a tsunami warning within a few minutes, there may not be time for the affected people to totally evacuate the inundation zone (young, aged, octogenarians, ill, or disabled). Vertical evacuation systems are therefore very essential which can always be made for multipurpose activities. For coastal constructions facing the scarcity of construction materials, mixing water, mass man power, space and natural disturbances, 4D visualisation will sort out things and make projects more effective and can reduce the construction time.

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