FIELD SURVEY OF THE HISTORICAL AND ARCHAEOLOGICAL BUILDINGS IN CHITTAGONG CITY, IDENTIFICATION OF FAULTS AND RECOMMENDATION OF PROBABLE RETROFITTING MEASURES

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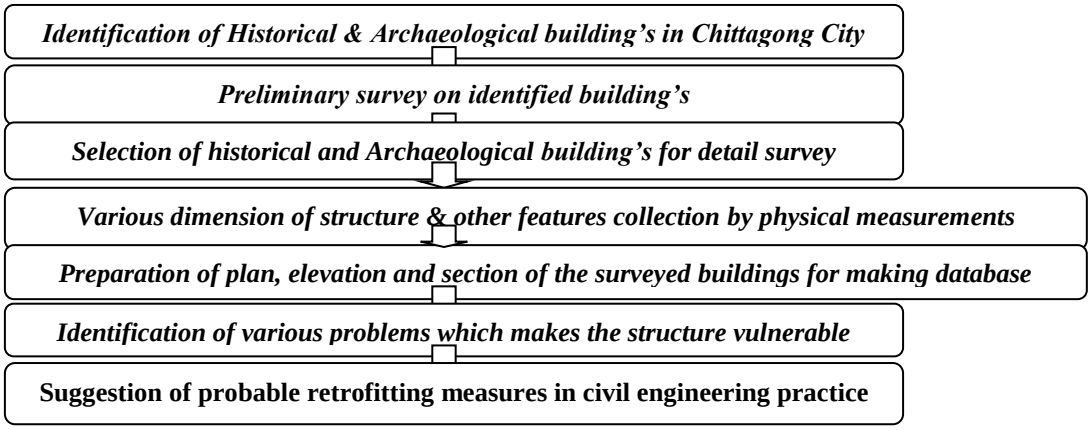
ABSTRACT
The history of Chittagong is very royal for many branches of history. The oldest archaeological and historical buildings are one of them. Near about 53 number of historic building are situated in Chittagong. Most of them are about to ruin due to age and lack of maintenance. At the same time the buildings have experienced different types of natural disaster like earthquake, flood, landslide, cyclone etc. Our most valuable traditional oldest archaeological and historical buildings are now at vulnerable condition due to frequent occurrences of natural disaster specially for earthquake and landslide. It is high time to take necessary steps to keep these buildings safe. Here we conduct a preliminary and detail survey on Chandanpura Mosque, CRB (Chittagong Railway Building), Zia Memorial Museum, Chittagong Railway Station (old), Chittagong Railway School, Chittagong Polytechnic Institute, Chittagong Club and Chittagong Court Building. Various dimensions of structure and other features collected by physical measurement from existing building's and prepare their floor plan, front elevation, sectional elevation. By visual observation we identified their visible faults. Then categorized them in plaster cracks, brick wall cracks, corrosion in steel, horizontal cracks in the beam, vertical cracks in the column.Then recommend probable retrofitting measures in civil engineering practice according to identified problem.

Keywords: Historical Building; traditional value; vulnerability; cracks; retrofitting

INTRODUCTION
Notable numbers of buildings are carrying our tradition, culture & history. Many Buildings are informally constructed in a traditional manner without formal design by qualified Engineers or Architects. Now a days this is become our responsibility to save this structures to conserve their traditional, historical and archaeological value.
Chittagong is also very important for its many historical & archaeological buildings. Such buildings involve stone, brick, concrete block, rammed earth and wooden post, combination of some or all above materials. For last six decade these buildings are completely out of proper maintenance on time. As a result they are almost nearby to damage before design life time. It is high time to take necessary action to save these structures. Most of them have not been designed for seismic loads. Recent earthquakes have shown that many such buildings are seismically vulnerable and should be considered for retrofitting. Retrofitting is the process of saving the structure from damage and strengthens the structure. Different conventional retrofitting techniques are available to increase the strength or ductility of these historical and archaeological building.

METHODOLOGY

Methodology of the work are given below as a work flow diagram



Identification of Historical & Archaeological building's

For identifying a project as a historical & Archaeological a building must satisfied three common criteria e.g. Age, Integrity of a Building and Significance.

Age: A building must be "old enough" at least 50 years old to be considered historic. In another way a structure must be old enough to have been studied by historians, architectural historians or archaeologists. This latter perspective allows some types of properties that are less than 50 years old to be considered as "historic".

Integrity: For physical integrity a building, structure, landscape feature, historic site, or historic district must be relatively unchanged. For an archaeological site, integrity means that the site must be relatively undisturbed, with its patterns and layers of artifacts and other archaeological evidence relatively intact.

Significance: Finally and most importantly a property must be significant to be considered historic. Significance is defined in three ways: (1) through direct association with individuals, events, activities, or developments that shaped our history or that reflect important aspects of our history; (2) by embodying the distinctive physical and spatial characteristics of an architectural style or type of building, structure, landscape, or planned environment, or a method of construction, or by embodying high artistic values or fine craftsmanship; or (3) by having the potential to yield information important to our understanding of the past through archaeological, architectural, or other physical investigation and analysis.

Preliminary survey on identified building's

We have conducted a preliminary survey of identified buildings by a questionnaire survey form shown in **Table 1**

Data collection

We collect data by field measurement and for required data we create a data base.

Preparation of Plan, Elevation & section

From surveyed data and field measurement we have prepared floor plan, front elevation and sectional elevation of surveyed buildings.

Fault identification

From visual investigation and field visit we have identified different types of fault on the existing structures e.g. plaster crack, beam column crack, ceiling crack, reinforcement corrosion, slab & stair problems, masonry wall crack.

Retrofitting measures

After identification of all types of faults we recommend required retrofitting measures.

RESULTS AND DISCUSSIONS

The 2nd largest city and sea port of Bangladesh, Chittagong has its past glory. During the 18th and 19th centuries Chittagong was under the British rule. For this reason different important historical and archaeological buildings were constructed in here in different times. The Preliminary Survey results are shown in Table 2

Table 1: Questionnaire survey form for preliminary survey

Sl. No.	Description of building	Information	Notes
01	Name		
02	Address		
03	Name and type of owner		Private/government
04	Name of Architect		
05	Name of Engineer		
06	Use of building		Residential/ office/ commercial/ industrial
07	Type of structure		Load bearing/frame
08	Open ground storey	Yes / No	
09	Heavy machinery or any other type of large mass	Yes / No	
10	Expansion / Separation joints		
11	Photograph / sketch		Attach with sheet
12	Structural drawings available	Yes / No	
13	Architectural drawings available	Yes / No	
14	Geotechnical report available	Yes / No	
15	No. of Storey		

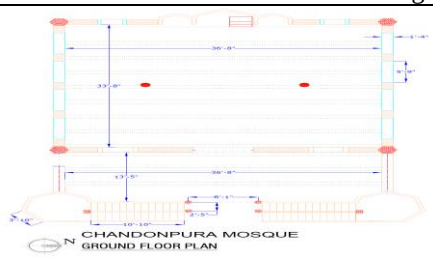
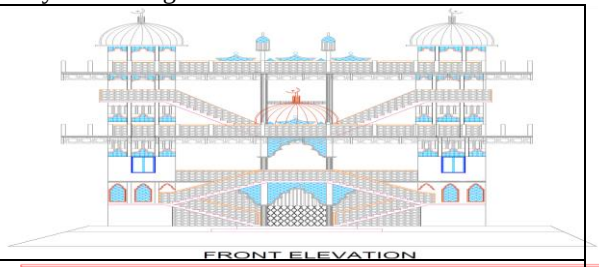
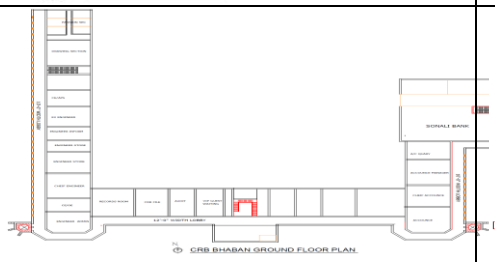
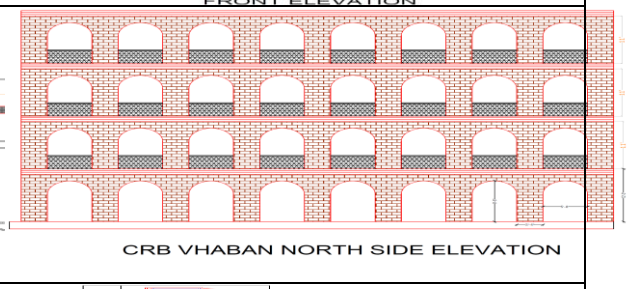
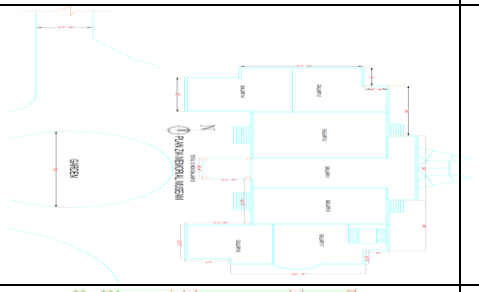
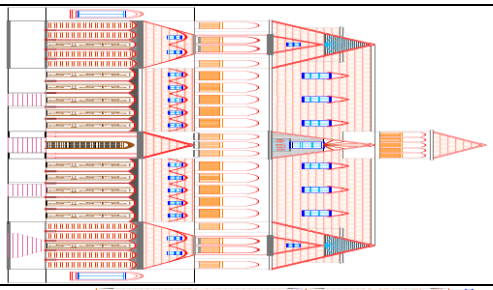
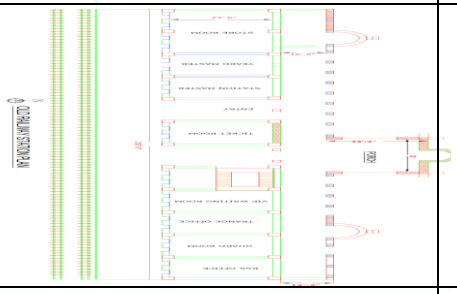
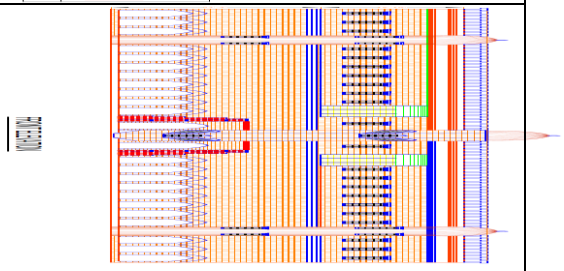
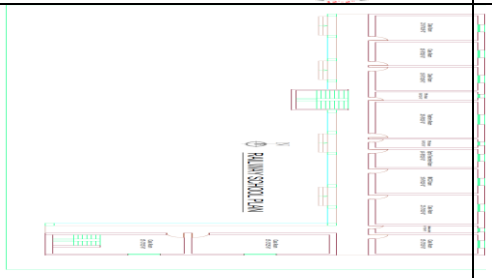
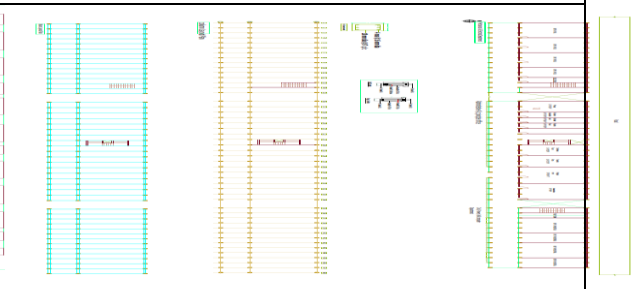
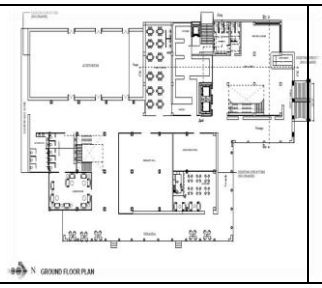
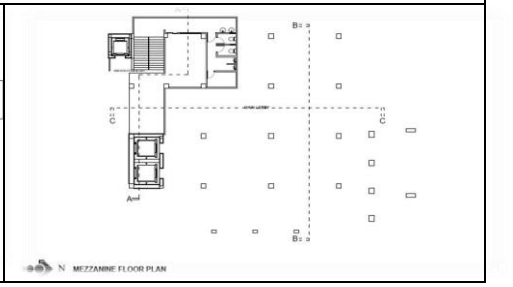
Table 2: Preliminary survey results

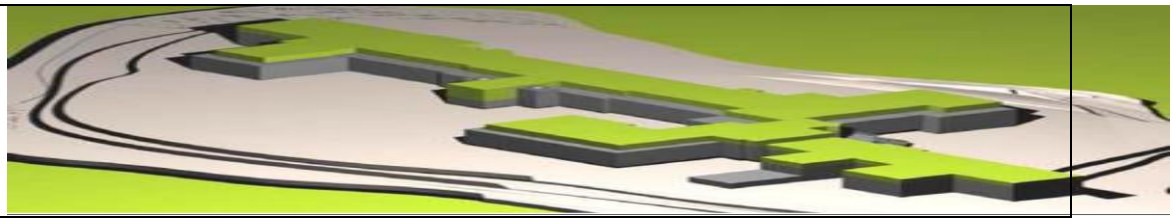
Sl. no.	Name of the building & Location	Established Year	No. of storied	Previously Retrofitted	Type of Structure
1.	Chandanpura Mosque<Andarkilla>	1920	02	No	Bricks masonry & RCC Structure
2.	CRB (Chittagong Railway Building)<S.S.Khaled Road>	British Victorian Period.	03	No	Bricks masonry
3.	Zia Memorial Museum<S.S.Khaled Road>	1913	02	No	Bricks masonry
4.	Chittagong Railway Station(old) <Kotowali>	1972.	02	Yes	Bricks masonry
5.	Chittagong Railway School <Pahartoli station road>	1936	02	No	Bricks masonry
6.	Chittagong Polytechnic Institute <East Nasirabad>	1962	03	No	R.C.C. frame structure
7.	Chittagong Club Ltd. <S.S.Khaled Road>	1875	03	Yes	R.C.C. frame structure
8.	Chittagong Court Building<Kotowali>	1953	03	No	Bricks masonry

Preparation of Plan, Elevation & section

Different floor plan and elevation drawn from collected data of the surveyed buildings shown in **Table 3**

Table 3: Drawing of surveyed building

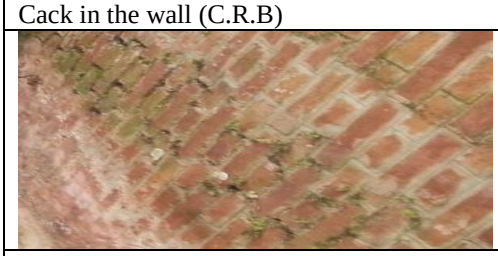
Chandanpura Mosque (Floor Plan & Front Elevation)		
CRB (Chittagong Railway Building) (Ground floor plan and North side elevation)		
Zia Memorial Museum (Ground floor plan and Front elevation)		
Chittagong Railway Station (Old) (Ground floor plan and Front elevation)		
Chittagong Railway School Building and Chittagong Polytechnic Institute (Ground floor plan)		
Chittagong Club (Ground floor , 1st floor, Mezzanine floor plan)		 

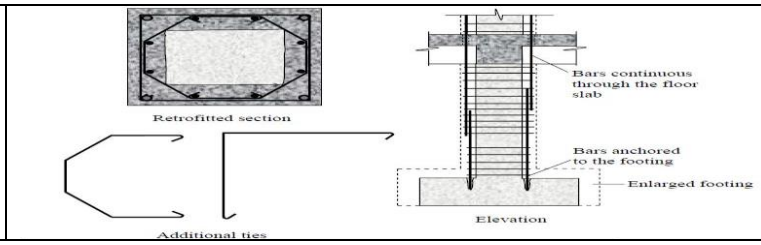
Chittagong Court Building Complex (3D Model View)	

Identified problems and their probable retrofitting measures

During detailed survey of structure identified problems and their probable retrofitting measures in civil engineering practice are shown in **Table 4**

Table 4: Identified problems and their probable retrofitting measures

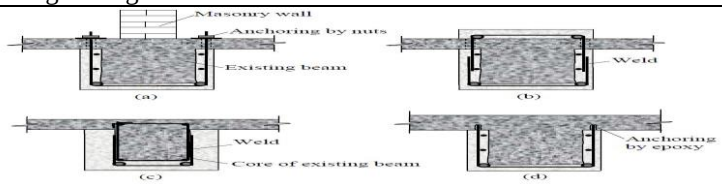
Crack in Ancillary part & plaster of the structure		
Cracks in railing and corrosion of steel (Chandanpura mosque).	Cracks in railing (Chandanpura mosque)	Cracks in the wall plaster (C.P.I).
		
Repair technique: Plaster should remove properly in cracks area. Then apply de-salt chemical in the wall and re plaster . Ancillary part like railing crack fault should recast.		
Crack in the wall		
Cack in the wall (C.R.B)	Corrosion in the wall (C.R.B)	Cracks in the wall (old fire service building)
		
Repair technique: Cracks that are small in width (≤ 0.75 mm) can be effectively repaired by pressure injection of epoxy (IS 13935: 1993).The surfaces are thoroughly cleaned of loose materials. Injection ports are placed along the length of the cracks on both sides, at intervals approximately equal to the thickness of the member. Low viscosity epoxy resin is injected into the ports sequentially, beginning at the port at the lowest level and moving upwards one by one. The resin is pushed through the packer till it is seen flowing from the other end or from a port higher than where it is injected. The port is closed at this juncture and the packer is moved to the next higher port. Larger cracks will require larger packer spacing depending on thickness of the member. Vacuum injection has a typical fill level of 95 percent and can fill cracks as small as 0.025 mm. A similar technique can be applied to strengthen weak walls. ***Re-pointing*:** For re-pointing, first the wall should be made wet and all loose debris cleared. The joints that are to be re-pointed should be raked to a depth of 2 times the joint height. Next fresh mortar should be placed by trowels. The mortar should be non-shrinking type. The re-pointed portion should be cured properly. ***GroutFilling*:** Selected cells in a hollow block masonry wall can be filled with grout. Filling the voids with grout will increase the compressive strength and make the wall more impermeable to water penetration. The inside of the cavity should be pre-wetted, then drained prior to grouting. ***Crack Stitching*:** It is possible to introduce internal ties in a masonry wall by drilling a hole, placing a bar and finally grouting the hole. A similar 'pinning technique' can be used for stitching cracks in the walls and strengthening the arches.		
Cracks in the column		
Cracks in column (C.P.I)	**Repair technique**: Column jacketing method can be applied for re-strengthening the column	



Cracks in the Beam

Crack & corrosion of steel in beam (C.P.I)

Repair technique: Beam jacketing method can be applied for re-strengthening the beam



Ceiling fault

Corrosion of steel on roof (C.P.I)

Corrosion of steel on roof (Court building)

Repair technique: Ceiling should re plaster after removing the old damaged plaster immediately to prevent steel corrosion and in R.B slab (reinforced brick) steel section can be repaired by applying anti corrosion chemical.

Cracks on the floor

Cracks on the floor (C.R.B)

***Repair Technique* :** Large Cracks and Crushed Material

For cracks with width larger than 6 mm or in regions where brickwork or concrete is crushed, the following procedure is suitable.

1. Removed loose material in the crack.
2. If necessary, the crack is dressed to have a V grove.
3. At wide cracks, fillers like flat stone chips can be used.
4.To prevent widening of the cracks, they can be stitched

The stitching consists of drilling small holes of diameter 6 to 10 mm on both sides of the crack, cleaning the holes, filling up these with epoxy mortar and anchoring the legs of stitching dogs (U-shaped steel bars of diameter 3 to 6 mm with short legs). The stitching dogs can have variable length and orientation. The spacing of the reinforcement should be reduced at the ends of the crack. Stitching will not close the crack, but it prevents further propagation and widening of the crack. The stitching will stiffen the area near the vicinity of the crack.

CONCLUSION AND RECOMMENDATION

CONCLUSION

In a sense of social & professional responsibility of an Engineer we take some step as starting of the preservation of Historical and Archaeological buildings. From above study we saw that identified problems are not a major problems at all. These can be easily retrofitted by suggested retrofitting measures in civil engineering practice in a economic way. Problem is lack of awareness, lack of regular repair & maintenance. In this way we throw our most valuable Historical and Archaeological buildings in a threat.

RECOMMENDATION:

- This paper can be used for conservation of these historic Structures.
- Prepared database can be used for taking priority of treatment at vulnerable stage.

- Can prepare a master plan for restoring the Historical Buildings in future.
- Data base can be used for the numerical modelling to get the specific retrofitting technique of this building.

REFERENCES

Handbook on Repair and Rehabilitation of RCC Buildings (2002), Central Public Works Department.
Hand Book on Seismic Retrofit of Building, Central Public Works Department.
IS13945, Repair and Seismic Strengthening of Buildings –Guidelines, Bureau of Indian Standards, New Delhi, 1993.
Shri. Pravin B. Waghmare "MATERIALS AND JACKETING TECHNIQUE FOR RETROFITTING OF STRUCTURES" International Journal of Advanced Engineering Research and Studies E-ISSN2249 – 8974.
UNDP/UNIDO Project RER/79/015,"Repair and strengthening of Reinforced Concrete, Stone and brick Masonry Buildings", Building Construction Under Seismic Conditions in the Balkan Regions, 1983, United Nations Industrial Development Programme, Austraia, Vol.5.