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Foundation Failure of the St. Thomas Church, New Delhi

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SYNOPSIS - The St. Thomas Church was built in 1933 in New Delhi. By oversight it was founded on a graveyard having graves at two levels. The comparatively heavy rains of 1958 and 1964 showed wide spread damage by differential settlement and tilting of tower. During the investigations in 1959 by the Central Building Research Institute, Roorkee, the earlier history of the site and church was examined. It was found that excessive damage had occurred in 1943 also and underpinning of foundations and butressing of walls was done to arrest it. Collapse of graves below the foundations was the reason for damage which reoccurred, mainly in the portions which were not underpinned or partially underpinned. Effectiveness and feasibility of remedial measures vis-a-vis the soil investigations are discussed.

THE SITE

Location - The St. Thomas Church is located on Reading Road, now known as Mandir Marg (Fig.1). The area between the Mandir Marg and the Upper Ridge Road is the Eastern slope of the Ridge. The church and the adjacent buildings are situated in a filled up shallow valley near the junction of Panchkuin Road with Mandir Marg. The Ridge is upto 25m higher than the general ground level in the Church compound which is at RL 221.3m.

History of the Site - Delhi is one of the most ancient and historic cities of India. The earliest reference is found in the famous epic Mahabharata, when Delhi was known by the name of 'Indraprastha' and it may be assigned a period of 15th century B.C.

There is some evidence that there were stone quarry pits around the site of the church. The 'Samadhis' higher up the slopes indicated that the Hindus used to cremate there while the Muslims started using the shallow valley as burial ground.

Delhi was declared the capital of British India in 1911 and New Delhi was laid out. When the construction of the residential quarters in 1915 reached as far as the site of the St. Thomas Church an outcry was raised due to Muslim graves. As a result the graves were covered by clean soil, site was left vacant, and the construction of Clerk's quarters began on the Northern side of the site. This was the site offered to Padre Weller and was accepted. The church was built in 1933 and Walter George was the architect for it. It may be recalled that the period of twenties and thirties was a period of great constructional activity in New Delhi. The famous Viceroy's House, now known as the 'Rashtrapati Bhawan', which is the official residence of the President of India, was designed by Sir Edwin Lutyens and completed in 1929.

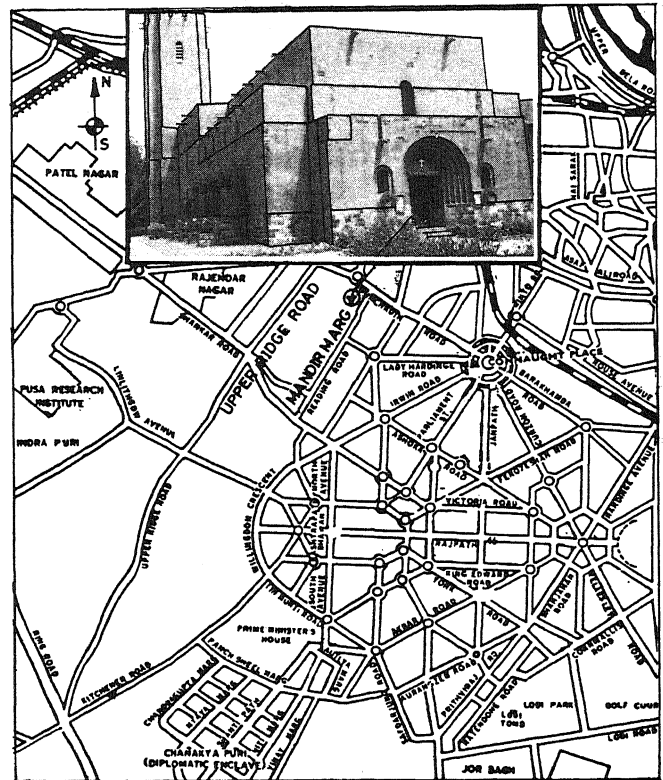


Fig.1 LOCATION OF ST. THOMAS CHURCH, NEW DELHI

THE BUILDING

The church is 103ftx56ft (31.4mx17.1m) in plan (Fig.2). It is a brick structure in lime mortar with a vaulted arch roof. The stone masonry, in local stone, as seen on the outside (Fig.1) is upto 4ft 6in (1.37m) above DPC. The tower was 61ft 10½in (18.86m) high. The buttresses (Fig.1) were not an original feature of the building and were added 10 years later in 1943. The tower is accessible through a winding staircase located in the North corner

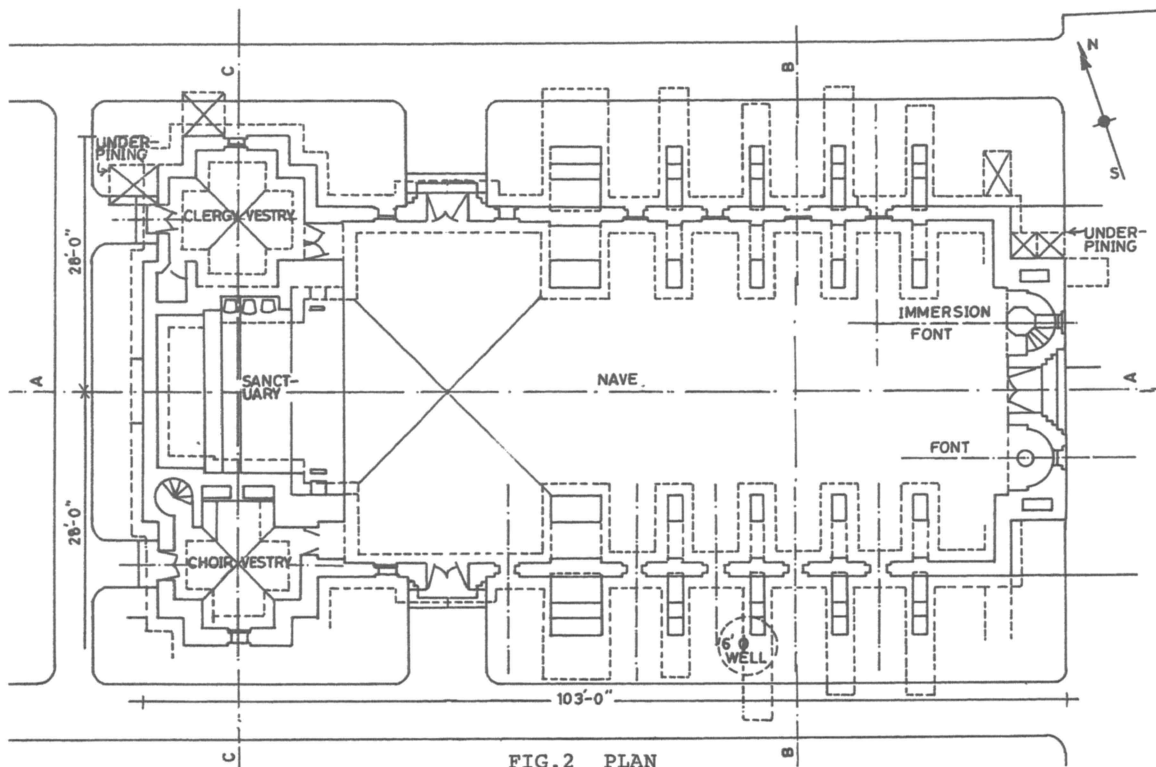


FIG.2 PLAN

of the Choir Vestry. The Nave was provided with 296 seats. The drawings showed that strip footing foundations of 4ft 6in (1.37m) depth below the floor were used originally for the most part of the building. At present the building shows no signs of damage from the outside as it has been repaired from time to time. However, a closer look of the interior will show uneven floors, damage to the railing in the front of the sanctuary, broken door sills and distorted door arches - indicating uneven sinking.

NATURE OF THE PROBLEM

Widespread cracking and sinking occurred after the heavy rains in 1958. The problem aggravated and in early 1959 the Central Building Research Institute was approached for investigations. It was observed that the tower had settled 4in to 6in (10cm to 15cm) showing cracks, wider at top and upto ground, at its junction with longitudinal and transverse walls of the church. The tower tilted away from the building towards the West corner. There was severe cracking of walls of the Clergy Vestry, Fig.3. Floor sills of stone and arches over doors and window also showed cracks. The entire portion comprising of the Choir Vestry, the Sanctuary and the Clergy Vestry separated from the Nave by tilting backward and showing through crack in the roof arch. Majority of cracks were slant along the diagonals. Differential settlements of floors showing sinking along the walls and heaved up centre were conspicuous.

The soil investigations were taken up in March - April, 1959 and findings were reported.

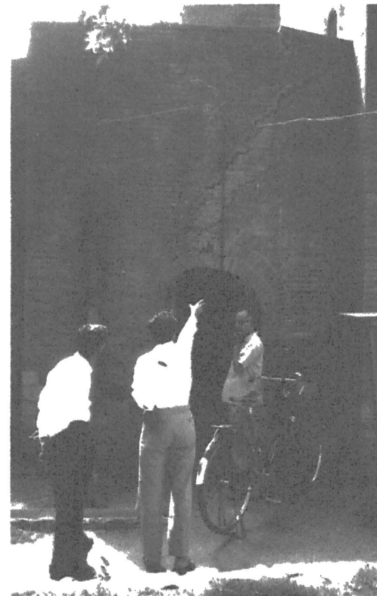


FIG.3 CLERGY VESTRY

The architect of the church provided the details of the problem and remedial measures adopted by him prior to 1958.

The problem of similar damage was again reported in 1964 after the end of rainy season. Cracking reoccurred on the locations repaired earlier. As the soil investigations had already

been carried out in 1959, only the settlement of the building by taking levels around it was monitored and was discontinued after no change was observed in 1965 and 1966 readings.

THE SOIL STRATA

The Choir Vestry, the Sanctuary and the Clergy Vestry were the most cracked portions. The soil investigations were carried out near these portions. For undisturbed sampling three open pits were dug and five static cone penetration tests were carried out (Fig.4) in March-April 1959. The soil test data are summarised in Fig.5. Undisturbed samples were used for oedometer tests. Additional two pits close to the tower faces were dug for ascertaining the actual depth of the foundations and the examination of the strata. The depth of the foundation below the tower was confirmed at 4ft 6in (1.37m) below ground level. There was a clear evidence of filled up soil. In pit No.4 graves were encountered at 6ft 6in (2m) and 8ft 6in (2.6m) and in pit No.5, these were at 7ft (2.1m) and 8ft 6in (2.6m) depths below ground level.

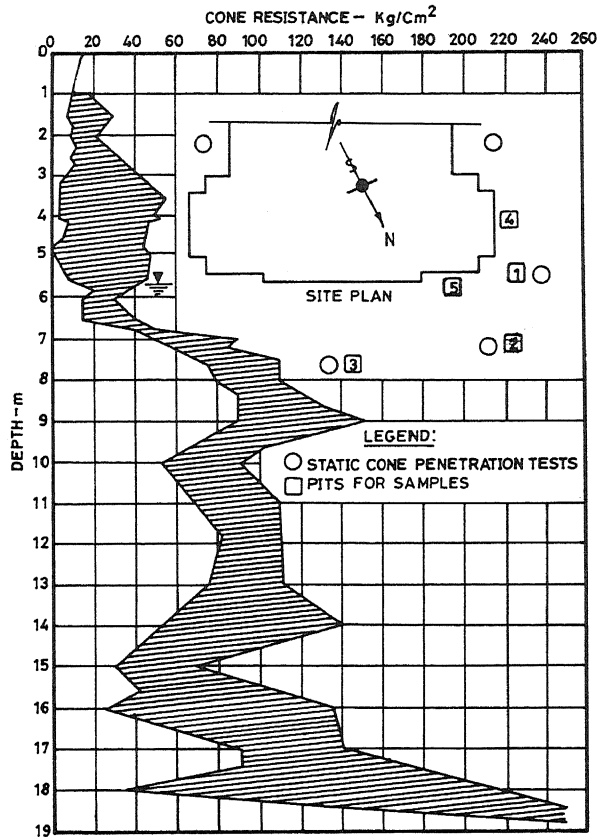


FIG.4 TEST LOCATIONS & STATIC CONE RESISTANCE

THE PROBLEM AND REPAIRS BEFORE 1959

During the course of investigations by the Central Building Research Institute, Roorkee, the architect provided the information about the repairs of the church building since its construction in early thirties. It was reported

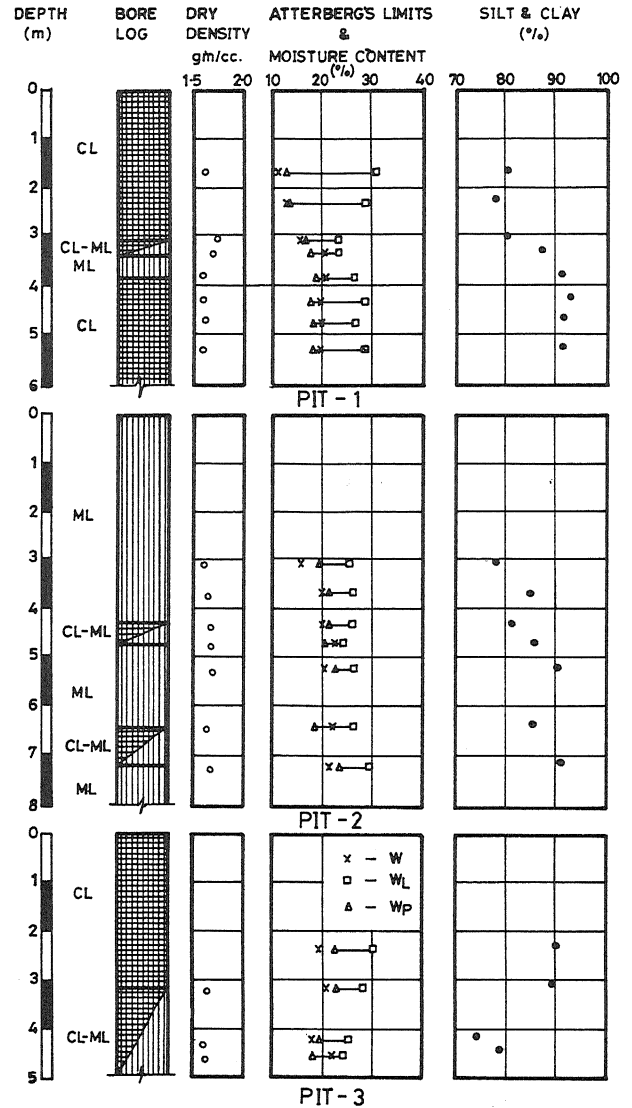


FIG.5 BORELOGS & SOIL TEST DATA

that severe cracking of the building first occurred in 1942. The architect resorted to underpinning of the foundations as shown in some of the sections of the building in Fig. The underpinning was not done below the tower and the Sanctuary. The Clergy Vestry was partially underpinned. The Nave was fully underpinned. The depth of underpinning, depending upon the availability of firm strata, varied from about 11ft (3.35m) to 14ft 6in (4.4m) below the ground level.

During the course of excavation a number of graves were encountered as indicated in two typical sections (Figs.5 & 6). Barring a few cases, there are two levels of burials at about 2m and 2.6m. It was on record that a pit dug at the Clergy Vestry near the West face revealed a burial at 11ft 3in (3.4m) alongwith an earthen pot containing an egg and two coins of 1835 and 1838, East India Company. The typical orientation, head towards West (direction of the holy 'Kaba') was clearly suggestive of the Muslim burials.

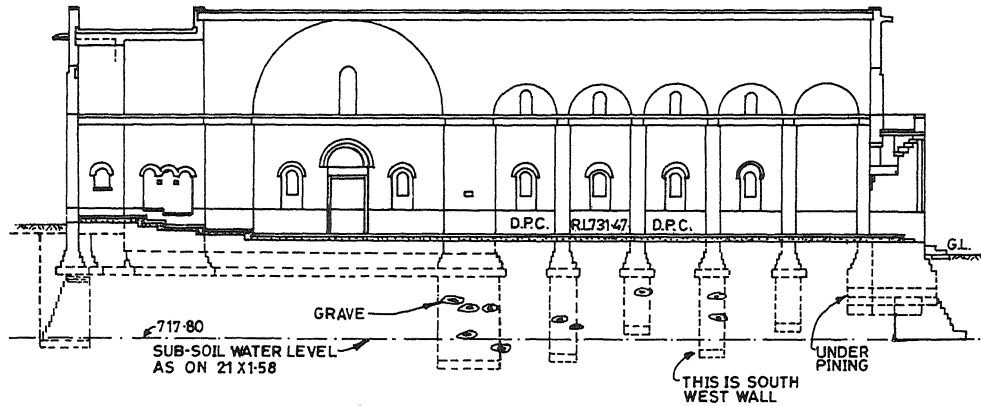


FIG. 6 SECTION ON AA

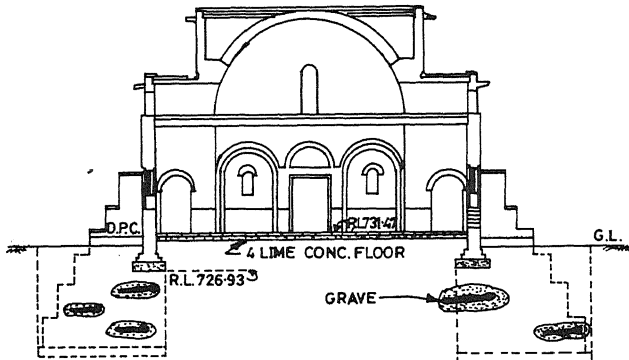


FIG. 7 SECTION ON BB

After underpinning operations the buttresses (Fig.1) were also provided for additional support for the longitudinal walls. The underpinning of the Clergy Vestry was at the outer accessible corner only.

DISCUSSION ON REASONS FOR DAMAGE

The soil sampling from the open pits showed that it was a filled up ground. However, top yellowish and greyish coloured soils with some 'Kankar' could be easily mistaken to be virgin ground. The architect reported that no soil investigations were carried out as the ground upto about 2m depth showed firm deposit. The site was a couple of feet higher than the surrounding ground at the time of construction, but the architect concluded that there had been a little excavation to get a uniform slope for the road. Thus the site was considered good enough to sustain a pressure of 1.5t/sq.ft (1.5 kg/cm²) transferred from the footings of the building. Till 1942 when cracking occurred and remedial measures by under pinning were taken up, the existence of graves was not suspected.

The method of burial is such that a hallow space remains at the top of shroud and it gets filled up in due course. The major reason for the collapse of these hollow spaces seems to be the seasonal rise in water table. During the investigations in April 1959 the water table was at a depth of 16ft (5m) and it was reported to be about 6ft (1.8m) during the rains, which is quite close to the footing level. The receding water table caused the

collapse of hollows which were indicated by the penetration test showing little or no resistance at certain elevations and confirmed by open excavations. The scatter of curves indicate variability of a filled up ground (Fig.4).

It is worth noting that more damage of sinking and cracking was noticed in 1958-59 in the tower and sanctuary portions which were not on foundations strengthened by underpinning (Fig.8). The Clergy Vestry was partially underpinned at the corner and this resulted in substantial damage. The underpinned corner remained in position while the adjacent portions showed sinking along with the backside wall of the sanctuary.

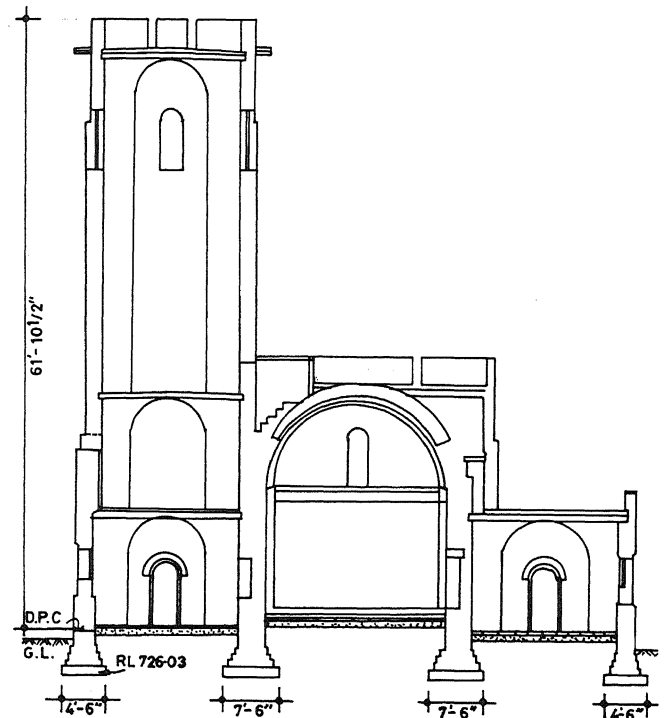


FIG. 8 SECTION ON CC

Due to erratic scatter of graves at two levels it is difficult to make a realistic settlement estimates. On 3rd March 1959, the tower had settled by about 5.5in (14cm) at its corner.

The inclination towards South and West were 9.75in (25mm) and 4.5in (11mm) respectively. On 28th September the tilt towards South was 8.35in (21mm) showing a recovery of 4mm.

In June 1964 settlement of the building was monitored at 19 points on the outer walls. The settlements were active upto October 1964 and during a period of three months the Tower, Sanctuary and Clergy Vestry (excluding the underpinned corner) showed settlements of the order of about 8mm while for the longitudinal walls it was less than 2mm. In November 1964 settlements stabilised and there was no further sinking upto 1965 when observation were discontinued. It is worth noting that in both the years 1958 and 1964, the rainfalls were higher than the average.

THE REMEDIAL MEASURES

As stated already the foundations were underpinned in 1943 from the firm ground. But the Tower and sanctuary were left as such. This led uneven support from the bearing strata. Buttresses were also provided in 1943, however, they do not seem to fulfill much useful purpose as the problem is more of downward sinking rather than the outward rotation of the walls.

In 1959-60 shoring in Fig.9 was done at the two outer sides of the tower and similarly at the Clergy Vestry walls. The support for shoring at the ground is derived from shallow concrete filled trenches. This shoring has outlived its useful life and as seen in 1986 it is partially rotten and now a relic from the past.

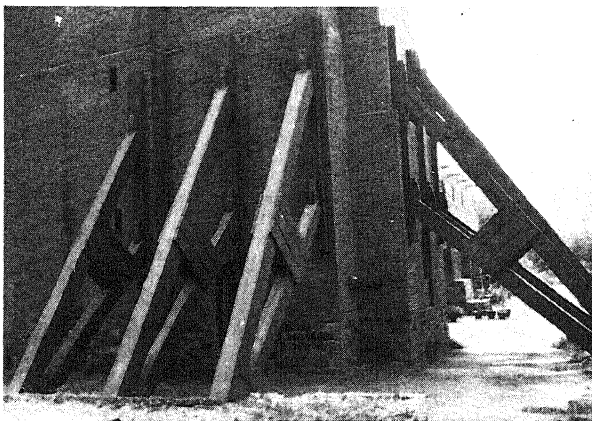


FIG.9 SHORING AT TOWER

Apart from the above measures, there had been a discussion on the feasibility of the other permanent measures as well. Reducing the height of tower for providing a relief in loading on the foundations was a proposal but of marginal help as architectural look was to be preserved. Grouting by cement slurry and underpinning by piles and beams were considered. Grouting was rejected because the strata were predominantly of silt and clay, 80-90 percent, and soil will not accept grout. The pile and beam proposal was not implemented due to specialised handling and the economy considerations. The desirable depth for support from firm strata is around 7m as seen from penetration records (Fig.4) and this means working below water level.

In view of the above no special remedial measures after those of 1943 were taken up. The superstructure and the floors were repaired from time to time. The building is in continuous use.

CONCLUDING REMARKS

The history of the St.Thomos Church once more focusses the attention on the importance of proper soil investigations prior to construction. Also the foundation treatment by remedial measures, by underpinning should be such that it provides uniform support. Otherwise the untreated portions may sink later.

ACKNOWLEDGEMENT

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The work was carried out as a normal programme of research and the paper is being published with the permission of the Director, Central Building Research Institute, Roorkee, India.