Bulletin of the Government Museum, Chennai

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GENERAL INTRODUCTION & SUMMARY

Endowment Lectures are a prestigious occasion for any institution with academic pretensions. The Government Museum, Chennai functions not only as a storehouse of knowledge through its collections but also disseminates the knowledge. It serves as a centre to bring the knowledge it possesses to the scholars and lay public through its Monthly Popular Lecturers (started circa 1870 AD and revived two years ago), training programmes and publications.

Endowment Lectures are delivered by eminent scholars, who usually have done some original and pioneering work in their field. Like much else, some discontinuity had crept into the delivery of these lectures on a regular basis. I am happy that this has been set right and the backlog and current lectures due for the years 1999 and 2000 AD for the Professor T. Balakrishnan Nayar Endowment are being delivered in May 2001 on 16-5-2001 AD and 21-5-2001. Professor T. Balakrishnan Nayar was a doyen of history and former Principal of the Presidency College, Chennai (Madras). The First Rao Bahadur Vemuru Ranganatham Chetty Endowment 2001 AD is also being delivered on 17-5-2001 AD. The former endowment is for lectures on history while the latter is on conservation. In keeping with the trend which started with the International Women's Association Endowment Lecture of 2000 AD delivered by Prof. K.V. Raman, publication of the lectures is being done on the day of the lectures itself. The three lectures have been combined in this volume since they represent a series delivered within a week.

History and Conservation are but two sides of the same coin. Excavations tell the tale of civilisations past but the excavated objects have to be preserved, if they should continue to tell their story. Further each generation views the finds in a different light with the help of the knowledge from other and newer disciplines - a view that I have stated in my book ' A holistic approach to Dating in Ancient History especially Indian history' (Kannan Dr.R., 2000). Fresh finds make us revise our opinion on earlier finds. Conservation of ancient buildings and monuments helps us to know what history has to tell us.

The three lectures are on different topics. In the Professor Balakrishnan Endowment lectures 1999 AD, we get a theoretical analysis of why and how the freedom struggle with its emphasis on non violence and mass mobilisation succeeded in throwing off the yoke of a mighty colonial empire from Dr. Sudhakar. He emphatically refutes the now fashionable theory that the tired rulers left us after the bleeding of World War II. World War II by itself was not the côup de grace. It was the culmination of a bleeding struggle of half a century, which succeeded in uniting a mass of diverse people into having a common aim i.e. Swaraj (independence). The key however lies in one sentence of Dr. Sudhakar's - ' the constitutional space provided by the existing structure was used without getting co-opted by it'. The battle of the minds - destroying the feeling among the Indians, that the British Raj was benevolent and invincible, was also won by Mahatma Gandhi and the freedom struggle. Fear was overthrown. The inclusive

character was slightly dented by the British. The 'Divide et Impera' policy according to Dr. Sudhakar succeeded in creating loyalist caste movements and of course the partition. While the caste factor could be subsumed in the national movement, partition did take place. The British, he theorises retreated, when they lost their mental hegemony over the Indian. However, they did not attempt to rule by the sword, because this was not feasible. One must add the French in Indo-China tried to rule by the sword and failed. Therefore, credit must be given to the British for beating a retreat with grace leaving a trail of friendship for them. ' Hate British Imperialism not the British' - as Dr. Sudhakar states was the motto of Indian nationalism. Whether this strategy would have succeeded with a more ruthless power with a dictatorial government is an oft asked question. 'The answer is that if all the Indians mobilised no power could keep them down for long without bleeding itself dry.

In the First Rao Bahadur Vemuru Ranganatham Chetty Endowment Lecture 2001, Professor Mathews speaks of the need to preserve and conserve historical monuments and artefacts from an engineering and European perspective. He delves into the causes for decay and damage to cultural property and how much to intervene with old heritage structures. He feels that prevention of further deterioration is the first step followed by preservation of status quo and restoration. He gives a spectrum of eight degrees of intervention which ranges from the minimum level i.e. prevention of further deterioration to the maximum level i.e. Reproduction of a valuable lost historic relic or past and Translocation i.e., locating in a different place like the Temple of Abu Sinbel as a result of Aswan High Dam.

He then analyses the elements in historic buildings, which need to be treated like walls, roofs, structural elements etc. As a conservation engineer, he has propounded a method called Finite Element Analysis to determine the degree of damage. He deals with the current topic of Earthquakes, fashionable now due to the recent huge Gujarat earthquake and how buildings are to be treated to make them earthquake proof to the extent possible. He goes on to analyse historic building materials like mortar. He gives some scientific investigation methods like endoscopy and treatment methods like stitching, micro piling etc. He cites examples from European experience using these methods. The lecture gives a good overview for archaeologists into conservation and preservation of monuments using the latest western techniques. He urges us to use them for our benefit.

Mr. K. T. Narashiman, Superintending Archaeologists, has done a lot of practical work in conservation of historical structures, monuments and temples with great success. He uses typically Indian low cost and appropriate technology in an Indian milieu. He gives a blow by blow account of how he directed the restoration of the historic royal palace complex and the throne of the Ginjee Nayaks which had fallen into a terrible condition of disrepair. The Ginjee Nayaks ruled from Ginjee, (in present Villupuram district) in the 15^{th} and 16^{th} centuries AD. He narrates how even the terracotta pipe which provided water supply to the bathing tank of the royal ladies was unearthed. This showed the mastery over water supply and lifting techniques in the Vijayanagar period. This writer along with Curators Mr. Lakshminarayanan and Mr. Mohan saw a similar

excavation currently in progress opposite to the Queen's bathing complex in Hampi, where there was a similar system of terracotta pipes for bringing water to the Queen's bath (see Photo). Since the Nayaks were feudatories of the Vijayanagar rulers, the idea must have come from Hampi. This lecture is a practical demonstration of the theoretical perspectives of conservation.

Of the three lectures the first analyses the history of freedom to learn how and why the British Empire could be overthrown by the methods adopted - that it was unique in world history. The second lecture deals with the theoretical and practical approaches to conservation of historical monuments from an engineering and European viewpoint. Of course, we should make use of such technology. The third is a case study on restoration of a historical monuments using traditional Indian methods and technology which was most successful in the case of such a type of heritage structure.

These lectures instead of being merely narrative as is as is the bane of much learning in India, analyse history in the case of the lecture on the freedom struggle and the theory and practice of conservation respectively in the other two lectures. I hope they will provide a fertile ground for future research. It is said 'History repeats itself because men/women commit the same mistakes' - These lectures, we hope, will stimulate us to learn from the past how not to commit mistakes - but function constructively to bring a better future to India.

R.Kannan

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Bio Data of the endowment Lecturers

Dr. G. J. SUDHAKAR

Dr. G.J. Sudhakar, was educated both at the Madras Christian College and the Jawaharlal Nehru University at New Delhi. He is presently serving as a Senior Reader in History in the Loyola College, Chennai. He has been an Examiner for several universities and colleges in South India. He has been guiding scholars at the Post graduate and research level. He has also been reviewing books on history, education for journals and newspapers. He is the Founder-Treasurer of Tamil Nadu History Congress and he is presently the Joint Secretary of Tamil Nadu History Congress. He has several research papers to his credit and he is the editor of the Journal of Indian History and Culture published by the C.P. Ramaswamy Aiyer Foundation, Chennai.

PROF. M..S.MATHEWS

Prof. (Dr.) M. S. Mathews with 37 years of teaching experience is at present working in the Building Technology Division of the Civil Engineering Department,Indian Institute of Technology, Chennai-36. He got his B. Tech., M. Tech. and Ph. D. from the Indian Institute of Technology. His field of research is restoration of monuments and in building technology and renovation of monuments and modern materials of construction. He has visited several European countries and several articles to his credit.

THIRU K.T. NARASIMHAN

Thiru K.T. Narasimhan has passed M.A. (Sahitya Siromani), Shiksha Sastri, B.O.L., P.G.Diploma in Archaeology. He started his career as a Lecturer and Assistant Superintendent, Deputy Superintendent in the Archaeological Survey of India. He had his intensive training in conservation in France. He is presently working as Superintending Archaeologist, Archaeological Survey of India, Chennai Circle. He has taken up and restored successfully scores of dilapidated monuments. He visited Vietnam recently to assess the damages to the monuments on the Vietnamese Government's invitation. He has many papers to his credit and scores of Sanskrit dramas and a critical edition of the Ramayana in Sanskrit.

PROFESSOR T.BALAKRISHNAN NAYAR ENDOWMENT LECTURE –1999 AD

The Indian National Movement – A Theoretical Perspective.

Dr. G.J. Sudhakar,

Prof. of History, Loyola College. Chennai-600 034.

The Indian National Movement was undoubtedly one of the biggest mass movements modern society has ever seen. It was a movement which galvanised millions of people of all classes and ideologies into political action and brought to its knees a mighty colonial empire. Therefore, it could be compared to British, French, Russian, Chinese, Cuban and Vietnamese revolutions.

The Indian National Movement, in fact, provides the only actual historical example of a semi-democratic or democratic type of political structure being successfully replaced or transformed. It is the only movement where the broadly Gramscian theoretical perspective of a war of position was successfully practised; Where state power was not seized in a single historical moment of revolution, but through prolonged popular struggle on a moral, political and ideological level; where reserves of counter- hegemony were built up over the years through progressive stages, where the phases of struggle alternated with `passive' phases.

The Indian national movement is also an example of how the constitutional space offered by the existing structure could be used without getting co-opted by it. It did not completely reject this space, as such rejection in democratic societies entails heavy costs in terms of hegemonic influence and often leads to isolation – but entered it and used it effectively in combination with non-constitutional struggle to overthrow the existing structure.

The Indian national movement is perhaps one of the best examples of the creation of an extremely wide movement with a common aim in which diverse political and ideological currents could co-exist and work – and simultaneously continue to contend for overall ideological and political hegemony over it, while intense debate on all basic issues was allowed, the diversity and tension did not weaken the cohesion and and striking power of the movement; on the contrary, this diversity and atmosphere of freedom and debate became a major source of its strength.

The path that India has followed since 1947 has deep roots in the struggle for independence. The political and ideological features, which have had a decisive impact on post – independence development, are largely a legacy of the freedom struggle. It is a legacy that belongs to all the Indian people, regardless of which party or group they belong to now, for the `party' which led this struggle from 1885 to 1947 was not then a party but a movement – all political trends from the Right to the Left were incorporated in it.

What are the outstanding features of the freedom struggle?

A major aspect is the values and modern ideals on which the movement itself was based and the broad socio-economic and political vision of its leadership (this vision was that of a democratic, civil libertarian and secular India, based on a self-reliant, egalitarian social order and an independent foreign policy.)

The movement popularised democratic ideas and institutions in India. The nationalists fought for the introduction of a representative government on the basis of popular elections and demanded that elections be based on adult franchise. The Indian National Congress was organised on a democratic basis and in the form of a Parliament. It not only permitted but encouraged free expression of opinion within the party and the movement; some of the most important decisions in its history were taken after heated debates and on the basis of open voting.

From the beginning, the nationalists fought against attacks by the State on the freedoms of the Press, expression and association, and made the struggle for these freedoms an integral part of the national movement. During their brief spell in power, from 1937-39, the Congress ministries greatly extended the scope of civil liberties. The defence of civil liberties was not narrowly conceived in terms of one political group, but was extended to include the defence of other groups whose views were politically and ideologically different. The Moderates defended Tilak, the Extremist and non-violent Congressmen passionately defended revolutionary terrorists and communists alike during their trials. In 1928, the Public Safety Bill and Trade Disputes Bill were opposed not only by Motilal Nehru but also by conservatives like Madan Mohan Malaviya and M.R. Jayakar. It was this strong civil libertarian and democratic tradition of the national movement which was reflected in the constitution of independent India.

The freedom struggle was also a struggle for economic development. In time, economic ideology developed which was to dominate the views of independent India. The national movement accepted, with near unanimity, the need to develop India on the basis of industrialisation. A crucial role was assigned to the public sector and, in the 1930s, there was a commitment to economic planning.

From the initial stages, the movement adopted a pro- poor orientation, which was strengthened with the advent of Gandhi and the rise of the leftists who struggled to make the movement adopt a socialist outlook. The movement also increasingly moved towards a programme of radical agrarian reform. However, socialism did not, at any stage, become the official goal of the Indian National Congress, though there was a great deal of debate around it within the national movement and the Indian National Congress during the 1930s and 1940s. For various reasons, despite the existence of a powerful leftist trend within the nationalist mainstream, the dominant vision within the Congress did not transcend the parameters of a capitalist conception of society.

The national movement was from its early days fully committed to Secularism. Its leadership fought hard to inculcate secular values among the people and opposed the

growth of communalism. And, despite the partition of India and the accompanying communal holocaust, it did succeed in enshrining Secularism in the Constitution of Free India.

It was never inward looking. Since the days of Raja Rammohan Roy, Indian leaders had developed a broad international outlook. Over the years, they evolved a policy of opposition to imperialism on world-wide scale and solidarity with anti-colonial movements in other parts of the world. They established the principle that Indians should hate British imperialism but not the British people. Consequently, they were supported by a large number of Englishmen, Women and political groups. They maintained close links with the progressive, anti-colonial and anti-capitalist forces of the world. A non-racist, anti-imperialist outlook, which continues to characterise Indian foreign policy, was thus part of the legacy of the anti-imperialist struggle.

The Indian National Movement had a certain specific, though untheorised, strategy of struggle within which its various phases and forms of struggle were integrated, especially after 1918. This strategy was formed by the waging of hegemonic struggle for the minds and hearts of the Indian people. The purpose was to destroy the two basic constituents of colonial hegemony or the belief system through which the British secured the acquiescence of Indian people in their rule; the British rule was benevolent or for the good of the Indians and that it was invincible or incapable of being overthrown. Replying to the latter aspect, Jawaharlal Nehru wrote in the Discovery of India: `The essence of his (Gandhiji's) teaching was fearlessness .... not merely bodily courage but the absence of fear from the mind ..... But the dominant impulse in India under British rule was that of fear, pervasive, oppressing, straggling fear; fear of the army; the police, the widespread secret service; fear of the official class; fear of laws meant to suppress and of prison; fear of the landlord's agents; fear of the money lender; fear of unemployment and starvation, which were always on the threshold. It was against this all-pervading fear that Gandhiji's quiet and determined, voice was raised: Be not afraid'.

And how was nationalist hegemony to be evolved? In the case of a popular anti-imperialist movement the leadership, acting within a particular ideological framework, exercises hegemony by taking up the anti-colonial interests of the entire colonised people and by unifying them by adjusting the class interests of the different classes, strata and groups constituting the colonised people. In the colonial situation the anti-imperialist struggle was primary and the social – class and caste-struggles were secondary, and therefore, struggles within Indian Society were to be initiated and then compromised rather than carried to an extreme, with all mutually hostile classes and castes making concessions.

Further, the nationalist strategy alternated between phases of massive mass struggle, which broke existing laws and phases of intense political – agitational work within the legal framework. The strategy accepted that mass movements by their very nature had ups and downs, troughs and peaks, for it was not possible for the vast mass of people to engage continuously in a long-drawn-out extra legal struggle that involved

considerable sacrifice. This strategy also assumed freedom struggle advancing through stages, though the country was not to advance to freedom till the threshold of the last stage was crossed.

Constructive work – organised around the promotion of khadi national education, Hindu-Muslim Unity, the boycott of foreign cloth and liquor, the social improvement of the Harijans and tribal people and the struggle against untouchability – formed an important part of nationalist strategy especially during its constitutional phases. This strategy also involved participation in the colonial constitutional structure without falling prey to it or without getting co-opted by it.

And what was the role of non-violence? It was not, we believe a mere dogma of Gandhiji, nor was it dictated by the interests of the propertied classes. It was an essential part of a movement whose strategy involved the waging of a hegemonic struggle based on a mass movement, which mobilised the people to the widest possible extent.

The nationalist strategy of a war of position, of hegemonic struggle was also linked to the semi-hegemonic or legal authoritarian character of the colonial state which functioned through the rule of law, a rule bound bureaucracy and a relatively independent judiciary enforcing extremely regressive laws and which extended a certain amount of civil liberties in normal times and curtailed them in periods of mass struggle. It also constantly offered constitutional and economic concessions though it always retained the basics of state power in its own hands.

Seen from this point of view, the peaceful and negotiated nature of the transfer of power in 1947 was no accident nor was it the result of a compromise by a tired leadership, but was the result of the character and strategy of the Indian National Movement, the culmination of a war of position where the British recognised that the Indian people were no longer willing to be ruled by them and the Indian part of the colonial apparatus could no longer be trusted to enforce a rule which the people did not want. The British recognised that they had lost the battle of hegemony or war of position and decided to retreat rather than make a futile attempt to rule such a vast country by threat of a sword that was already breaking in their hands.

The Indian National Movement was popular, multi-class movement. It was not a movement led or controlled by the bourgeoisie, nor did the bourgeoisie exercise exclusive influence over it. Moreover, its multi-class, popular and open-ended character meant that it was open to the alternative hegemony of socialist ideas.

The national movement did, in fact, undergo constant ideological transformation. In the late 1920s and 1930s, Jawaharlal Nehru, Subhas Bose, the communists, the Congress Socialists, and other left-minded socialist groups and individuals made an intense effort to give the movement and the National Congress a socialistic direction. One aspect of this was the effort to organise the peasants in Kisan Sabhas, the workers in trade unions and the youth in youth leagues and student unions. The other was the effort to give the entire national movement a socialist ideological orientation, to make it adopt a

socialist vision of free India. This effort did achieve a certain success and socialist ideas spread widely and rapidly. Almost all young intellectuals of the 1930s and 1940s belonged to some shade of pink or red. Kisan Sabhas and trade unions also tended to shift to the left. Also important in this respect was the constant development of Gandhiji's ideas in a radical direction. But, when freedom came, the left had not yet succeeded, for various reasons, in establishing the hegemony of socialist ideas over the national movement and the dominant vision within the movement remained that of bourgeois development.

The Indian National Congress, being a movement and not just a party, included within its fold, individuals and groups which subscribed to widely divergent political and ideological perspectives. Communists, Socialists and Royists worked within the Congress as did constitutionalists like Satyamurthy and K.M. Munshi. At the same time, the national movement showed a remarkable capacity to remain united despite diversity, the lesson was learnt from the disastrous split of 1907 and the Moderates and Extremists, Constitutionalists and non-constitutionalists and leftists and rightists did not split the Indian National Congress thereafter, even at the gravest crises.

There were, of course, many other streams flowing into the swelling river of India's freedom struggle. The Indian National Congress was the mainstream but not the only stream. Pre-Congress Peasant and Tribal Movements, the Revolutionary terrorists, the Ghadar and Home Rule Movements, Akali and Temple Reform movements of 1920s, INA, Rin Revolts etc. These "Non-Congress" movements were not 'parallel' streams, as some have maintained. Though they were outside the congress, most of them were not really separate from it. They cannot be artificially counterposed to the movement led by the congress, which, with all its positive and negative features, was the actual anti-imperialist movement of the Indian people incorporating their historical energies and genius, as is the case with any genuine mass movement.

In fact, nearly all these movements established a complex relationship with the congress mainstream and at no stage became alternatives to the congress. They all became an integral part of the Indian national movement. The only ones, which may be said to have formed part of an alternative stream of politics were the communal and casteist movements which were not nationalist or anti-imperialist but in fact betrayed loyalist pro-colonial tendencies.

In time, the Indian National Movement developed into one of the greatest mass movements in World History. It derived its entire strength, especially after 1918, from the militancy and self-sacrificing spirit of the masses. Satyagraha as a form of struggle was based on the active participation of the people and on the sympathy and support of the non-participating millions. Several Satyagraha Campaigns – apart from innumerable mass agitational campaigns – were waged between 1919 and 1942. Millions of men and women were mobilised in myriad ways; they sustained the movement by their grit and determination. Starting out as a movement of the nationalist intelligentsia, the national movement succeeded in mobilising the youth, women, the urban petty bourgeoisie, the

urban and rural poor, urban and rural artisans, peasants, workers, merchants, capitalists and a large number of small landlords.

The movement in its various forms and phases took modern politics to the people.

Even while relying on the popular consciousness, experience, perception of oppression and the needed remedies, on notions of good rule or utopia, the movement did not merely reflect the existing consciousness but also made every effort to radically transform it in the course of the struggle. Consequently, it created space for as well as got integrated with other modern, liberationist movements, movements of women, youth, peasants, workers, Harijans and other lower castes. For example, the social and religious reform movements which developed during the 19th century as part of the defence against colonialisation of Indian Culture merged with the national movement. Most of them became a part of the broad spectrum of the national movement in the 20th century. But, in the end, the national movement had to surrender in part before communalism. The national movement also failed to undertake a cultural revolution despite some advances in the social position of women and lower castes. Moreover, it was unable to take the Cultural defence of the late 19th century's social and religions reforms back to the rationalist critical phase of the early 19th century. It also could not fully integrate the cultural struggle with the political struggle despite Gandhiji's efforts in that direction.

The national movement was based on an immense faith in the capacity of the Indian people to make sacrifices. At the same time, it recognised the limits on this capacity and did not make demands based on unrealistic and romantic notions. "The nation has got energy of which you have no conception but I have", Gandhiji told K.F. Nariman in 1934. At the same time, he said, a leadership should not 'put an undue strain on the energy'.

As a mass movement, the Indian national movement was able to tag the diverse energies, talents and capacities of a large variety of people. It had a place for all – old and young, rich and poor, women and men, the intellectuals and the masses. People participated in it in varied ways: from jail going Satyagraha and picketing to participation in public meetings and demonstrations, from going on hartals and strikes to cheering the jathas of Congress volunteers from the sidelines, from voting for nationalist candidates in municipal,, district, provincial and central elections to participating in constructive programmes, for becoming 4-anna (25 paise) members of the congress, to wearing khadi and a Gandhi cap, from contributing funds to the congress, to feeding and giving shelter to congress agitators, from distributing and reading the Young India and the Harijan or the illegal patrikas (bulletins), to staging and attending nationalist dramas and poetry festivals, and from writing and reading nationalist novels, poems and stories, to walking and singing in the prathatpheries (parties making rounds of a town or part of it.)

The movement and the process of mass mobilisation were also an expression of the immense creativity of the Indian people. They were able to give a full play to their innovativeness and initiative.

The movement did not lack exceptional individuals, both among leaders and followers. It produced thousands of martyrs. But heroic were those who worked for years, day after day, in an unexciting, humdrum fashion, forsaking their homes and careers and losing their lands and very livelihood – whose families were often short of daily bread and whose children went without adequate education or health care.

FIRST RAO BAHADUR VEMURU RANGANTHA CHETTY ENDOWMENT LECTURE - 2001 AD

European Approach to Monument Preservation

Prof. M.S. Mathews

Civil Engineering Department

I.I.T. Madras

Introduction

Historic monuments are living documents of bygone times. They reflect the archeological, structural and constructional achievements of past times. It is the duty of the current generation to preserve the historic monuments passed on to us by our ancestors and give them to future generations. In this paper, the European approach to monument preservation is presented in a nutshell.

Organisation

1. Causes of decay and damage to cultural property.
2. Degrees of intervention
3. Structural Elements in Historic Buildings
4. Historic Materials
5. Modern Repair Methods
6. Investigation and Repair Methods for Timber
7. Foundations
8. Conclusions

1. Causes of decay and damages to cultural property (Fig.1)

The causes of decay can be categorised as follows
External Causes

- Climatic Causes

  - Daily temperature changes
  - Seasonal temperature changes
  - Precipitation
  - Ice and frost
  - Ground water and moisture

- Biological and botanical causes
  - Animals
  - Birds
  - Insects
  - Trees and plants
  - Fungi, mould and lichens

- Natural disasters
  - Earthquakes
  - Floods
  - Fire

- Internal causes
  - Humidity
  - Contaminated air
  - Neglect

- Man made causes
  - War
  - Pollution
  - Vandalism
  - Neglect of preventive conservation

2. Degrees of intervention

For a historic building eight degrees of intervention, in increasing order of altering the original form is possible.

1. Prevention of deterioration
2. Preservation of the existing state
3. Consolidation of the fabric
4. Restoration
5. Rehabilitisation
6. Reproduction
7. Reconstruction (Fig.2)
8. Translocation (Fig.3)

Prevention of deterioration

The very first step in the prevention of deterioration is the periodic cleaning of the building. If it is possible, an optimum environment (temperature and humidity levels) should be maintained inside. Heavy traffic can cause excessive vibrations of the structure. The lowering of ground water table due to excessive pumping should be avoided.

Preservation of existing state

Preservation can be achieved by stopping damage due to rising moisture, chemical agents (from atmospheric pollution), by preventing attacks by pests and micro-organisms.

Consolidation of the fabric

Consolidation is the addition of new material into the building, for example, grouting of the cracks in the walls. While adding new materials it is important to retain the original character of the buildings.

Restoration

Restoration is to revive the original concept of the buildings. For example, replacing the missing decorative elements in a building is restoration

Rehabilitation

Putting the building to its original use is best for conservation. But this is not always possible. Hence the adaptive use of buildings is a good way of preserving historic buildings.

Reproduction

Reproduction is the copying to replace a missing or decayed part in order to preserve valuable historical objects or materials

Reconstruction

This is the reconstruction of historic buildings using new materials. This may be necessitated due to the destruction of the building by fire, war or earthquake. The Frauenkirche in Dresden, Germany was destroyed during the war by bombing. This is being reconstructed as shown in fig.2.

Translocation

This is a rare form of restoration, where historic building is relocated from one site to another. An example is shown in fig.3.

3. Structural elements in historic buildings
Vertical support elements (Fig.4)

The vertical support elements mainly consist of column, piers and walls. The materials used in these elements are generally stone and brick.

The fig.4 shows typical stone columns used in historic buildings as tapered column and highly articulated column in stone. The problems with stone columns are that due to eccentricity of loading on them, crushing can occur where the fibre stresses exceed the material strength.

Wall elements(Fig.5)

Historic walls can be of different types. Some possibilities are shown in fig.5 They can be broadly classified as random rubble masonry and ashlar masonry. The ashlar masonry when it starts getting thicker and thicker becomes multi-leaved. In R.R. masonry, generally the two outer leaves will be filled with rubble masonry. The problems with these walls are that sometimes the core made of rubble losses its strength and then the two outer leaves alone will have to sustain the load. This may lead to excessive stresses in the outer leaves and can lead to failure. Another common problem in the walls is cracks due to the settlement of the foundations.

Roofing elements (Fig.6)

Roofing elements can be divided into two main groups (i) Roof trusses and (ii) Roof systems made from brick and stone. Timber roofs have been used extensively in ancient times and old times.

The fig.6 gives some of the roof forms in brick and stone masonry. Being naturally weak in tension, compression has to be mobilised to achieve the roof forms. Arches are not strictly roof forms, as they are one dimensional in nature. But arch forms the basis for the barrel vault and spherical domes. Semi-circular arches have greater vertical reactions and less horizontal thrust. A spherical dome is generated by the rotation of a semi-circular meridian about its vertical axis. The principal stresses of this surface are in the direction of the meridians and in the direction of the horizontal rings.

Problems in structural elements (Fig.7)

The arches can develop cracks due to the spreading of abutment or due to the differential settlement of one abutment.

The main problem with circular dome is the development of meridianal cracks in the lower portion of the dome.

The problems associated with the cross vaults are more complex.

The external buttressing system for the cross vault will give away slightly under the imposed thrusts from the vault and movements will occur during the first few years after the construction of the structure.

Finite Elements Analysis (Fig. 8)

In most cases of practical interest, the problem of calculating the stress distribution in a complex structure cannot be solved in a purely analytical way. The need to simplify the problem, from both the mathematical and the geometrical point of view, led to the development of numerical methods, some of which for example, were expressly designed to be employed in the form of calculation codes with today's fast and powerful computers.

The principle of FEM is based on the assumption that a complex continuous structure can be described as an assembly of a certain number of discrete continuous elements. Such elements, which are of finite volume and simple shape are connected to one another along the borders in a finite number of points called nodes. Code libraries are provided with several standard types of element configuration for the best approximation of the actual structure.

Dynamic Behaviour of Historic Building (Fig. 9,10,11)

The dynamic behavior of earthquakes is becoming more and more important. Depending on the intensity of the earthquake the damages to historic monuments can be very light to devastating.

Dynamic FEM can be applied to study earthquake problems.

4. Historic Materials

Historic Mortars (Fig.12)

Most historic mortars are lime mortars. The mortar generally consists of lime and sand. In addition to this, natural pozzolana and brick powder were also added. When repair mortar is used, the objective must be to develop a mortar as close to the original mortar as possible. In modern times there is a general tendency to use cement mortar. Cement mortar must never be used for the repair of historic buildings constructed using lime mortar. The following are the disadvantages when Portland cement is used in the repair of historic buildings.

1) Its use is not reversible. When removed, it damages all historic buildings.
2) It is too strong in compression, adhesion and tension so that it is not compatible with the weak materials of historic buildings.
3) Because of its high strength it lacks elasticity and plasticity when compared with lime mortar, thus throwing greater mechanical stresses on adjacent materials and hastening their decay.
4) It is impermeable and has low porosity.

5) It shrinks on setting, leaving cracks for water to enter and because it is impermeable such water has difficulty in getting out. Therefore, it increases defects caused by moisture.
6) It produces salts on setting, which may dissolve and damage porous and valuable materials.

The conclusion is that Portland cement should not be used for mortars and plasters in historic buildings, but to achieve higher strength, a maximum of 10% of cement can be added.

***Investigation* Methods (Fig. 13,14)**

- Non-destructive Methods
  1) Sonic measurements
  2) Sonic tomography
  3) Radar investigation
  4) Thermographic analysis
  5) Rebound tests
  6) Magnetometric analysis

- Slightly destructive methods
  7) Coring techniques
  8) Borehole video survey (Endoscopy)
  9) Flat jack tests
  10) Bore hole dialtometre

- **Borehole Video Survey (Endoscopy)**

It is possible to attach a miniature colour video camera to the tip of the shaft and this can be inserted in to the borehole. This allows a detailed study of both the front and sides of the hole. This can be processed in computer, which will give a good picture of the internal structure of the masonry

- **Flat jack tests (Fig.15)**

Flat jack can be used to measure the stresses in masonry in-situ. Two reference points are installed on the wall surface and the initial distance between the two points is measured. A cut perpendicular to the wall surface is then made and stress release occurs by the partial closing of the cutting, the distance after the cutting between the points would have reduced. A thin flat jack is placed inside the cut and the pressure is gradually increased to cancel the previously measured shortening. In this connection, the pressure measured by the jack is the stress in the masonry.

In brick masonry, cut is made along the mortar layer and rectangular jacks are used. In stone, diamond tipped steel discs are used to cut a groove and flat jacks of the same shape are used to measure the stress.

To obtain the stress-stain diagram for the masonry in-situ, a second cut parallel to first one is made and a second jack is inserted. The masonry between the two jacks represents a masonry block of reasonable size to which an uniaxial compression can be applied.

(5) Modern Repair Methods

- Temporary strengthening
- Grout injection
- Stitching
- Prestressing
- Strengthening with steel and reinforced concrete

Temporary Strengthening (Fig.16,17)

When an emergency intervention is required and there is no time to do an investigation, temporary- strengthening measures can be adopted these measures are generally reversible.
The column is strengthened by the provision of five steel collars. Timber pieces are provided between the collars and the column to protect the surface of the column.

The figure of temporary strengthening is showed in Fig.16 and Fig.17.

Grout Injection (Fig.18)

Purpose of grout injection

1. To strengthen loose mortar and masonry bond.
2. To close cracks, gaps and voids inside the wall structure
3. To increase the load carrying capacity of original masonry.
4. To make areas, which are strong enough to take larger forces due to changed use, loads or supports of new constructions.

Stitching (Fig.19,20)

Stitching as subsequent reinforcement happens where tension or thrust occurs, which the masonry cannot withstand. Stitching is always connected with grout injection to form the bond between the steel and masonry as well as to provide corrosion protection.

In multi leaf masonry the reinforcement bars connect the two outer leaves through the inner filling which is strengthened by injection. As the outer leaves are generally one stone thick, special attention must be paid to the anchorage of the bars.

As a rule bars made of ribbed reinforcement steel of grade 420/500 with a diameter of 8 to 20mm, mainly 12 to 16mm, with anchorage by bond are used. Also steel with through rolled threads ribs, so called Gewi-steel has proved useful with long anchor bars

a steel joint can be used, for example in damp walls. Steel without ribs should not be used as the bond is weak.

With 20mm cover for the reinforcement bar by cement in the drill-hole, corrosion protection is guaranteed.

Prestressing (Fig.21)

Old masonry is grouted and prestressed if strongly torn walls and pillars must be joined to regain their compressive strength, ability to sustain thrust and in addition to withstand tensile stress. Prestressing is also done when the masonry has to be self – supporting and span openings without auxiliary construction of steel or reinforced concrete, to strengthen the masonry located on weak coils leading to settlement problems. When the causes for the cracks are removed e.g. by improvement of the subsoil or reinforcement of the foundation, a loose armouring will be sufficient for securing the masonry. As a rule, prestressing is only applied in the case of severe damage of the masonry. With the help of prestressing, force flow may be corrected in old masonry constructions.

The most frequently used stressing tendons are steel rods with through rolled thread ribs on both sides, diameter 15 to 36mm, steel quality about 850/1050 to 1100/1350.

Prestressing Equipment

This is major operation requiring very expensive equipment and special expertise to carry out the drilling. Drilling long lengths through masonry, say 30m and more keeping the alignment straight is a major operation.

Strengthening with steel, reinforced concrete

Sometimes it becomes necessary to strengthen the historic buildings with steel and reinforced concrete. Four interesting cases are presented below.

The first is the case of the reinforcement of the spires at Faversham Almhouses Chapel, Kent, England (Coath 1991).

The twin spires of the church constructed in 1863 were removed in 1964 because they were thought to be structurally unsound. It was decided to reinstate them in 1987. The aim was to return the chapel to a form that respected the original design concept by reinstating the missing elements with minimal disturbance and intervention to the remaining structure whilst integrating current standards of construction and adopting modern design philosophy where appropriate.

The second case is that of the Fronteira Palace located in Lisbon, Portugal. It was built in 1584 (George 1993).

The columns have become so weak that it was decided to transfer the roof loads to a long steel truss girder.

The third case is that of the stone spires of Burgos Cathedral, which are strengthened by steel rings inside.

The fourth case is that of the strengthening of a 400 years old Ottoman Minaret built in 1590 and located in Thessaloniki.

Timber Repair Methods (Fig.22,23)

The repair of historic timber structures is a combination of science and art. First of all the engineer must be familiar with the various forms of historic timber structures. Some of the possible joining methods is shown is Fig.22 & Fig.23.

5. Investigation and Repair Methods for Timber

- Resistograph
- Core boring
- Moisture meter
- Wood testing hammer
- Stress wave timber

◻ Resistograph (Fig.24)

The resistograph graphically displays the profile of the resistance of a drill when it is driven into a timber section. The portable resistograph drill contains two DC motors, one responsible for the rotation of the needle (rotating speed 1000 to 2000 rpm) and the other one for the advance of the needle. The needle is stabilised within the drilling machine by use of a special telescope. The needle's tip is twice the diameter of the shaft. So the drill resistance mainly affects the tip and does not increase with penetration depth due to friction of the shaft. The mechanical drill is simply measured by recording the power consumption of the drilling machine. The drill resistance can be correlated to the dry wood (after suitable calibration).

◻ Wood testing hammer (Fig.25)

After long and careful calibration it will be possible to use it for strength prediction based on the resistance offered by the timber to the penetration of the standard needle.

◻ Moisture meter

The advantage of this equipment is that the variation of moisture levels, as a function of the depth of the electrode in the timber can be determined. The instrument actually measures the moisture content of the timber material between the two tips of the electrodes. The body of the electrodes is insulated.

- **Stress wave timber (Fig.25)**

The stress wave timber is a non-destructive method of determining the modulus of elasticity of the timber. The principle is to hit one end of the beam and with the help of a transducer at the other end of the beam measure the time taken by the stress wave to travel the length of the beam. This travel time in microseconds is related to the value of the value of the timber.

7. *Foundations*

- Increasing the area of foundation to decrease the bearing pressure on the soils.
- Micro-piling
- Soil nailing
- Soil-crete
- Soil-frac

- **Micro piling (Fig.26,27)**

This is the most popular method of strengthening the foundations of historic buildings. Micro piles are piles with a diameter of 100 to 300mm. They can be inclined up to 10^0. There are two methods of applying the micro piles. In the first case, the piles are driven at an angle through the existing foundation and grout is applied under pressure. In the second case, the piles are made vertical on both sides of the existing foundation. Then the pile system is made monolithic with the existing foundation by transverse prestressing. Sometime it is not possible to drive the piles close to the existing foundation, in which case a steel cross beam can be used to connect pile system.

Soil Nailing

This is a method developed by Prof. Erwin Schwing (1987). A lot of old masonry gravity-retaining walls in the Germany, built in natural stone with a height of 2m up to 8m and more are not safe enough. Cracks and bulges indicate the inadequate capacity of the wall. The wall can be stabilised by soil nailing which will reduce the active earth pressure. A concrete nail head on the face of the wall will not be acceptable from an aesthetic angle. The stages in the driving of the nailand forming a concrete nail head as follows.

First a hole is drilled in the stone wall and the soil. Next two secondary holes (one on the top and the another one on bottom) are drilled. Water is sent through top hole and it creates a valid space. Then the steel rod is inserted and grouting is carried out.

- **Soil Crete (Fig.28)**

This technique was developed by the Japanese, about 20 years ago. A hole is drilled in the soil. Then a pipe with a hole at the bottom is brought down to bottom of the hole.

Cement grout under pressure is sent down into the pipe. The pipe is rotated as shown in the figure. The grout comes out and displaces the soil, which is led up in the annular space to the surface of the ground. The tube in the rotating condition is gradually withdrawn and a cylindrical soil crete body is formed. The diameter of this cylinder depends on the period of rotation at each level.

- **Soil frac (Fig.29)**

The idea comes from the oil industry. A hole is bored in to the soil and grout is sent out at higher pressure. The grout fractures the soil and starts forming "grout roots" like that of a tree. The process is repeated several times till a full grown root system is established.

Conclusion

In the past 2 decades extensive research has been carried out in the area of Conservation Engineering in Europe. Many of the research results have been successfully applied to practical situations. In India we can study these approaches and utilise them with the necessary modifications to our own monuments with immense benefits.

RAO BAHADUR V.RANGANADHAM CHETTY

(Founder of Sri Venkateswara Students Hostel)

Rao Bahadur V.Ranganadham Chetty is one of the leading lights of Arya Vysya Community. He was born in January 1879. He is a philanthropist and devoted his entire life for promoting religious trusts, charitable endowments and educational institutions.

He took concrete efforts and initiative for publishing many valuable editions and epics. Moreover he brought out transactions of great Indian Epics. He is a trustee of so many temples and presented jewels and donated funds for renovating and administrating them.

He is the founder of Sri Venkateswara Students Hostel and awards are distributed for the deserving students out of its profit. Due to his yeoman service, the Government conferred on him the title Rao Bahadur. He was considering establishing hostel for women and also a Trust for the upliftment of the poor.

PROFESSOR T.BALAKRISHNAN NAYAR ENDOWMENT LECTURE –2000

NEW DISCOVERIES AT GINGEE

K.T.NARASIMHAN
Superintending Archaeologist
Archaeological Survey of India,
Chennai Circle.

Gingee, a Taluk Headquarters in Villupuram district was the capital for Gingee Nayaks, who succeeded the Great Vijayanagar rulers. The Gingee Nayaks were responsible for construction of several temples in and around Gingee. They were staunch Vaishnavites.

Besides they were responsible for the construction of Rajagiri Fort as well as Krishnagiri Fort at Gingee. These forts are classical examples for the Giri-Durga type of fort. Besides within the Rajagiri fort, several structures were built during their period like Kalyana Mahal, Granary, Royal Harem, Gymnasium and so on. They have introduced the Gopura architecture over the pillared mandapa which was not known earlier. A fine example is the 16 pillared mandapa with such gopura at Pattabirama Temple Complex in Narasingarayanpettai which is without parallel.

Unfortunately, the palace of Gingee Nayaks was totally fallen and buried. The Archaeological Survey of India, Chennai Circle,Chennai made an effort to discover all the buried architectural treasure. The excavation conducted during the last decade of the last century was so fruitful that through it the historicity of Gingee is very much enriched with the following new discoveries.

Within the Rajagiri Fort, the highly polished massive granite stone cushion was lying half-buried and the people used to say that the stone was used for gymnastics all these years. The excavation has revealed the real identity and utility of the said stone as a back rest for the King to conduct Darbar in the open court.

A 8m square platform was unearthed adjacent to the royal palace complex which was excavated few decades ago. In other words, a new discovery was made to the west of the Kalyana Mahal. On physical examination, the unearthed platform is identified as the royal throne. It has all the mouldings of adhisthana right from upana up to pada. The specialty of this platform is the swastik symbol in lotus petals which clearly reveals that this platform was made exclusively for the rulers for their throne. To strengthen this theory further, physical features are very helpful. The platform in question has got a flight of steps on all the cardinals. Another significant feature of this discovery in question is that it has a single highly polished greenish granite probably imported from Karnataka region which is capped on the platform. The previously mentioned highly polished granite cushion is fitted over the royal throne. It not only perfectly suits, but gives a grand look to this royal throne and one can understand that this polished stone was used as a backrest. It is identified as a backrest because it is cylindrical in shape

with a flat base having a bead design at the bottom so as to properly sit over the platform without any movement. Besides we have one more sculptural representation depicting a king resting on such stone cushion. In fact, that cushion is identical with this one.

A rectangular hall was unearthed. It is situated to the east of the original palace complex. In fact, it is connected with the palace complex through the flight of steps on the western side. This structure has got beautiful adhisthana mouldings with highly polished lime mortar having a prominent pada. A kumuda painted with ochre colour is worth mentioning. It has an underground water outlet on its south-east corner connecting to the stepped tank. At the centre of this structure there is a well without any toe-wall.

To the north of the royal throne there are many pillar bases which indicates there might have been a mandapa with perishable material. Besides there are two brick platforms at two different levels facing the royal throne, perhaps for seating arrangements of the audience according to their status.

In the Kalyana Mahal there is a stepped tank with a nirali mandapa at the centre. All round the tank a closed verandah was constructed. The back wall of this verandah serves as a screening wall to safeguard privacy to the required extent, since this stepped tank was used exclusively by the royal ladies.

While deplastering the steps, some unusual small openings were noticed by the Conservation Assistant of Gingee Sub-circle and reported to the Superintending Archaeologist. The chance discovery made by this circle is very unique and unparalleled in the Gingee Nayak period.

The ancient fountain was introduced by the builder in the stepped tank. Approximately 0.40 m below the existing floor level, a row of fountains was noticed. In other words, the floor level was raised at a later period without providing proper arrangements to these fountain outlets. In fact, the tops of the fountain outlets were concealed with a row of bricks. It is very clear that this arrangement was made at a later period, perhaps due to ignorance. The two different periods of construction can be seen from the different sizes of the bricks. In fact, the size of the original step's bricks perfectly tallies with the of the excavated Palace Complex bricks, where as the said row of bricks, (9 inch thick) for raising floor level, is a modern one.

On 14.10.1999, under my direction, all the fountain nipples were cleared and water was poured through the nipples. The poured water, going down 2 steps (4^{th} step from the bottom) flowed and came out through a fountain.

The said ancient fountain was made of terracotta. A terracotta pipe runs all around over the 4^{th} step from the bottom. Its diameter is 10.25 cm and thickness 1.2 cm. The terracotta pipes have a wide mouth on one side, without any edge. The diameter is reduced to 1.5 cm. at the bottom. Each such pipe was inter-linked with each other. This terracotta main pipe is covered on the exterior all around with country tiles. They were cemented with pure lime; even today it is very strong and unbreakable.

The said pipe has got openings on the top portion at a regular interval with a distance of 38.25 cm. From these a conical terracotta outlet was affixed. Its height is 64.5 cm. This pipe is not a single one. It has a number of such conical terracotta pipe; each one having a length of 6.5 cm and diameter of 5 cm. at the bottom and 3.5 cm at the top. Such terracotta pipes are fitted one over the other vertically. To get the required height (64.5 cm) at the top, a 6 cm long copper pipe is inserted. Inside the copper pipe, a small terracotta opening was fixed. Over the pipe a thick terracotta disc with a small nozzle is provided. This arrangement is made to obtain water pressure for making the fountain function and to safeguard the terracotta from external damage.

From the unearthed evidence, the engineering skill during the Gingee Nayak period can be judged.

Unfortunately, the main terracotta pipe is severely damaged due to a very thick live banyan root. The banyan root is noticed right from the south- west corner to the middle of the northern side.

On account of this enemy, the steps on the northern side might have collapsed in the past. Even as on date, a particular stretch on the northern side (approx. 2 metres in length) has sunk. When the sunken portion was removed, we noticed the terracotta main pipe, and the entire fountain system, besides the said banyan root running through the main pipe.

The unearthed ancient evidence should be properly conserved. Unless we know the water pumping system, it is not possible to make the ancient system functional. However, we were able to trace the original inlet and outlet on the southern side at two different levels.

Another important discovery was also made (on 14.10.199) in the same monument. I was told that during the last decade, a new entry was made to this monument on the south-west corner, after closing the then existing south-east entrance. The floor level was raised at the entrance to be on par with the floor of the verandah. To our surprise, the original floor level with lime plaster and side walls with a flight of steps (3) leading to the stepped tank was unearthed.

An inlet was provided at a later period through the said entrance by cutting a second step. This water canal was made with brick and lime, capped with dressed granite stone without using any mortar. This canal (inlet) comes into the tank from the south-west corner. However, its continuity has to be probed outside the verandah in due course.

Though the excavation conducted is on a small scale, it has revealed invaluable architectural treasure. Further major horizontal excavation may throw some light enabling us to know about the plan of the entire palace complex and other structural activities within the Rajagiri Fort at Gingee.

Supply to Queen's Water bath in
Humpi through terracotta pipes
(refer P.No. 3)

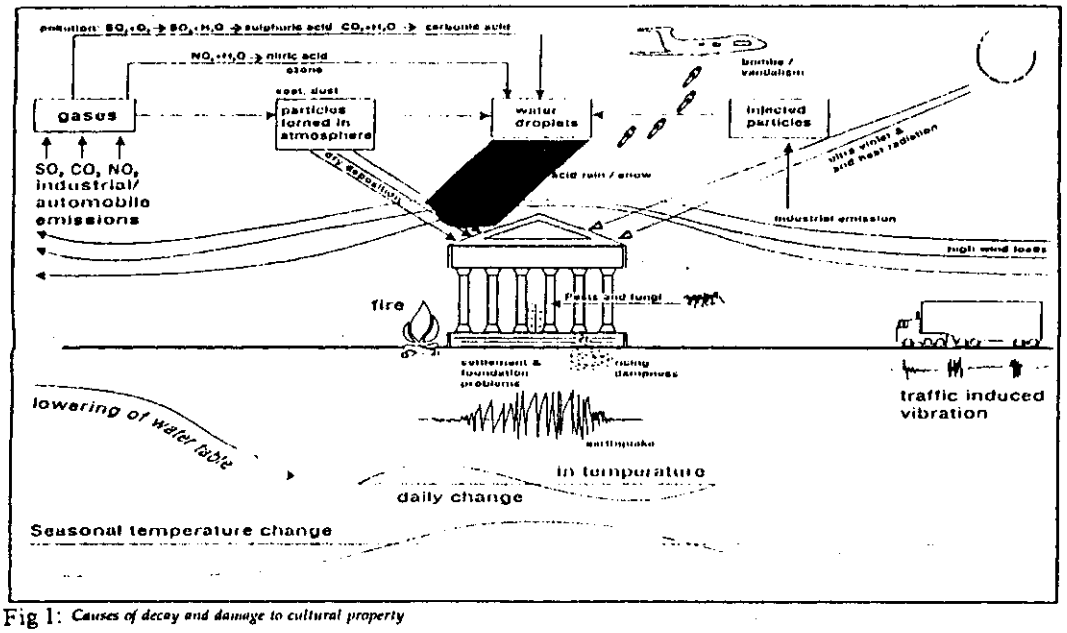


Fig 1: *Causes of decay and damage to cultural property*

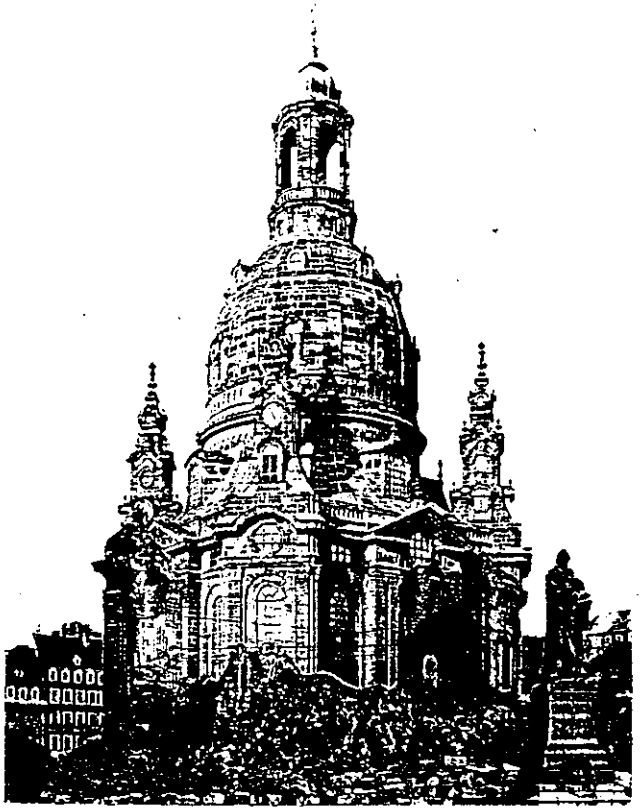


Fig 2: *Frauenkirche, Dresden, Germany (Guttler 1991)*

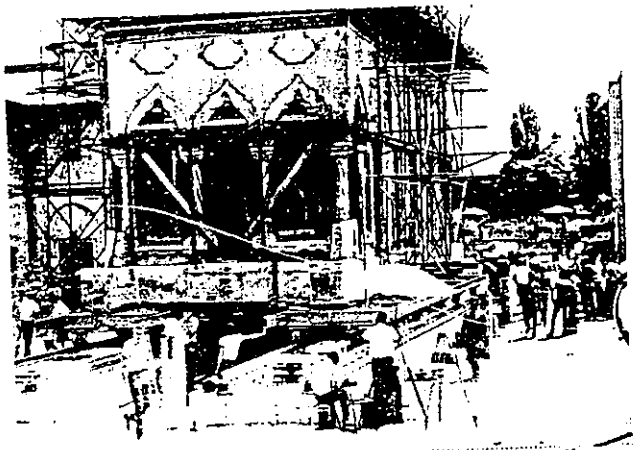


Fig 3: *Translocation of Historical Building (Paul-Emile Miclescu 1990, Monuments Historiques, June-July 1990)*

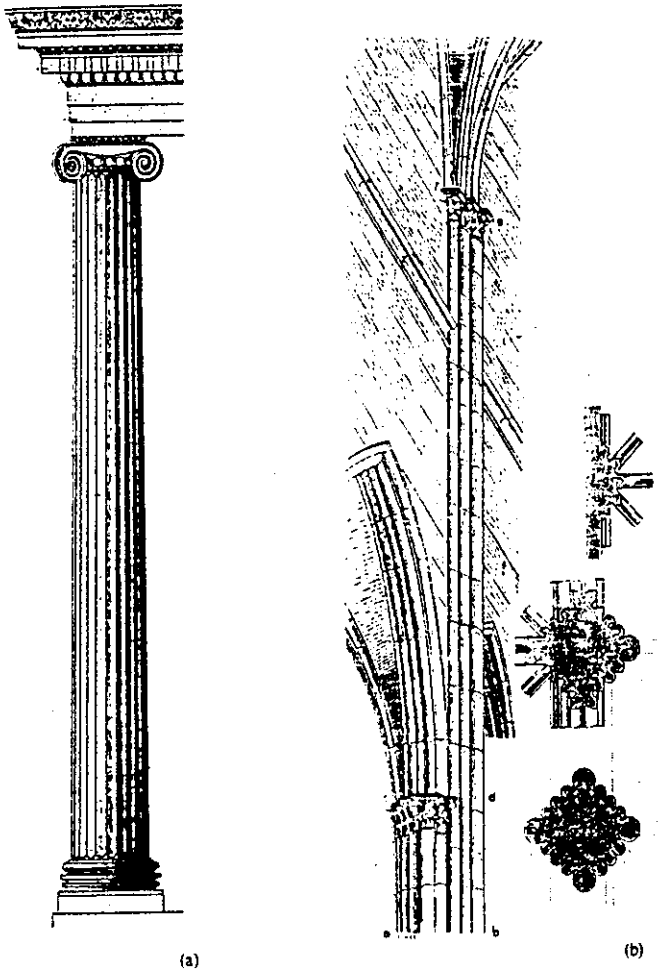


Fig 4: *Typical stone columns in historical buildings*
(a) Column of Greek Ionic order
(b) Stone Column (Warth 1903)

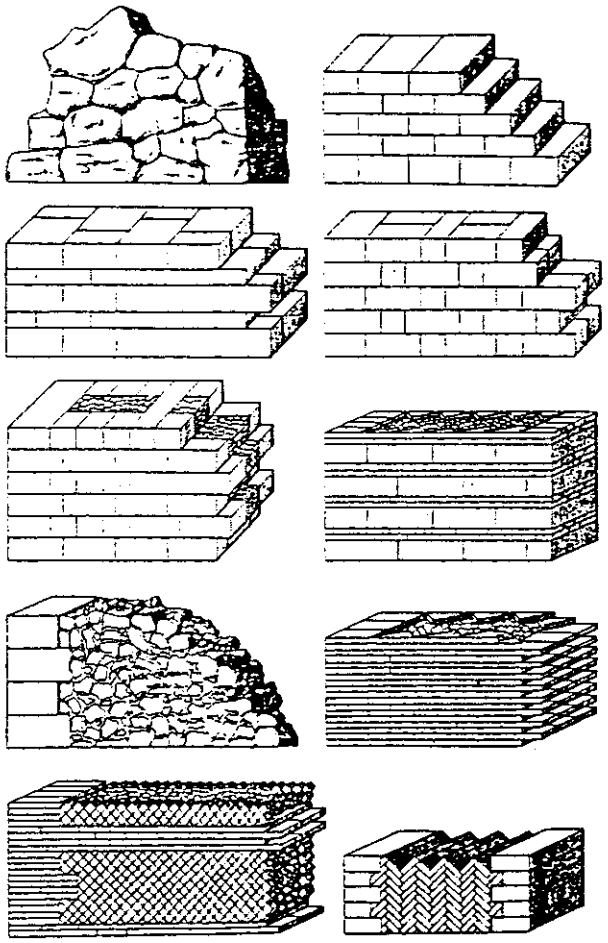


Fig 5: *Different types of stone walls (Warth 1903)*

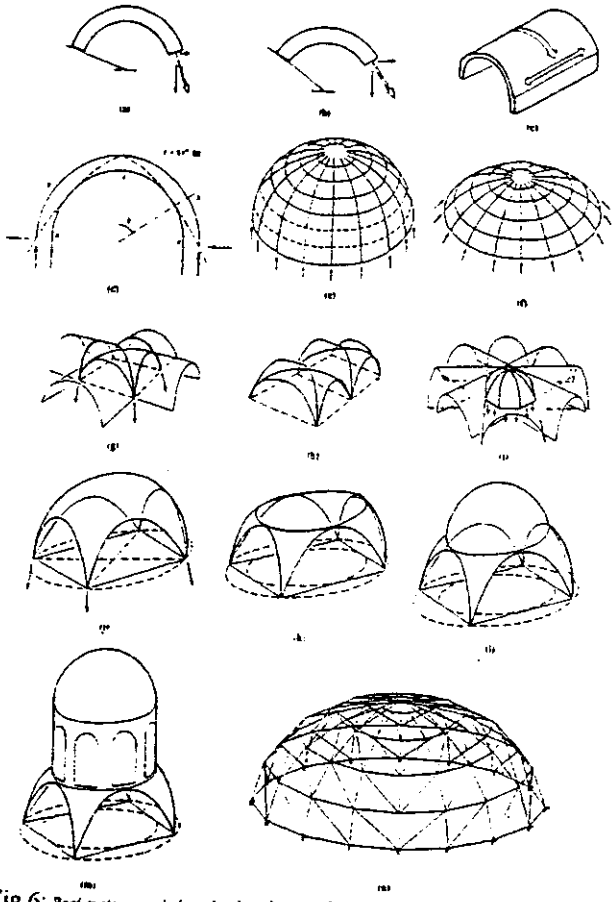
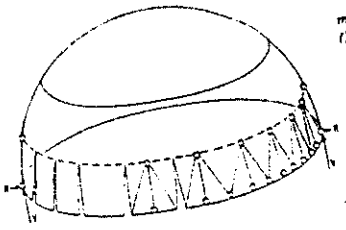


Fig 6: *Roof systems made from brick and stone (Ozsen 1991, Feilden 1982, Eschg 1995)*

(a) Circular arch
(b) Shallow arch
(c) barrel vault
(d) geometry of dome
(e) spherical dome
(f) shallow spherical dome
(g) groined vault
(h) double groined vault
(i) cloister vault
(j) Pendentive dome
(k) & (l) Dome on pendentive
(m) Drum on pendentive
(n) Mathematical Model of an elliptical dome

The cracking of a masonry dome in the lower portion (Pieper 1983)



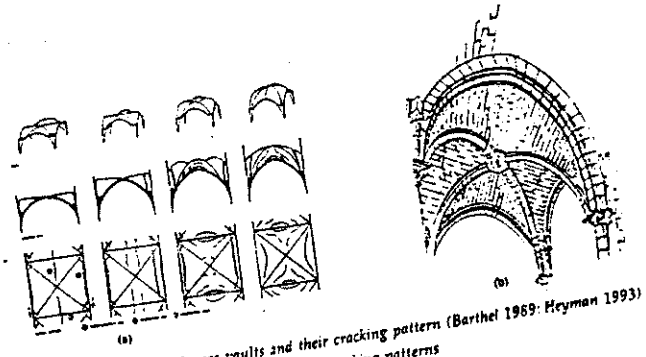
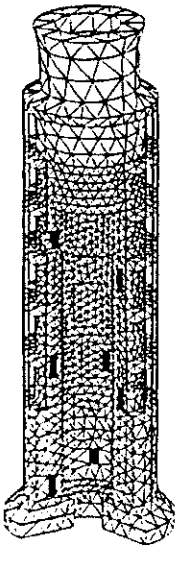


Fig 7: Basic types of cross vaults and their cracking pattern (Barthel 1989; Heyman 1993)
(a) Four basic types of cross vaults and their cracking patterns
(b) Schematic diagram of the cracks as seen from beneath

Fig 8: The finite element model of the Tower of Pisa (Macchi 1993)



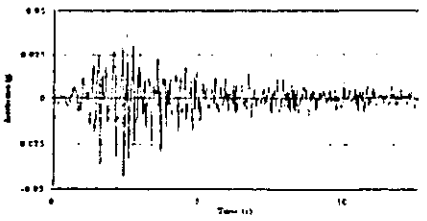


Fig 9: *Typical spectral acceleration*

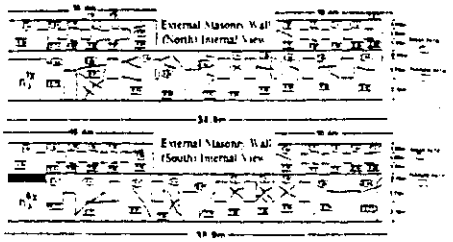


Fig 10: *Crack morphology due to earthquake (Manos 1997)*

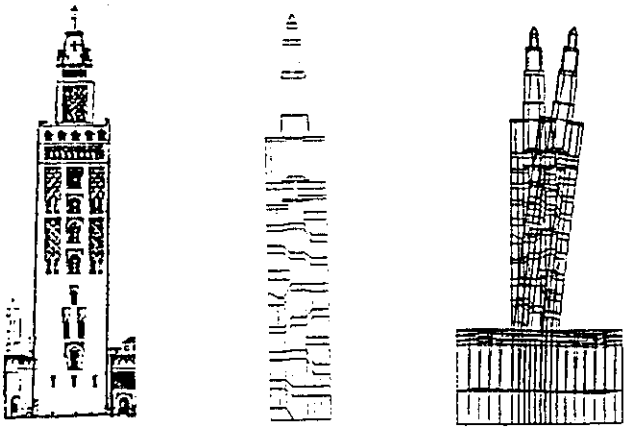


Fig 11: *Giralda Tower, Seville, Spain (Justo 1997)*
(a) Giralda Tower
(b) Finite element descretization
(c Vibration of the tower assuming deformable foundation

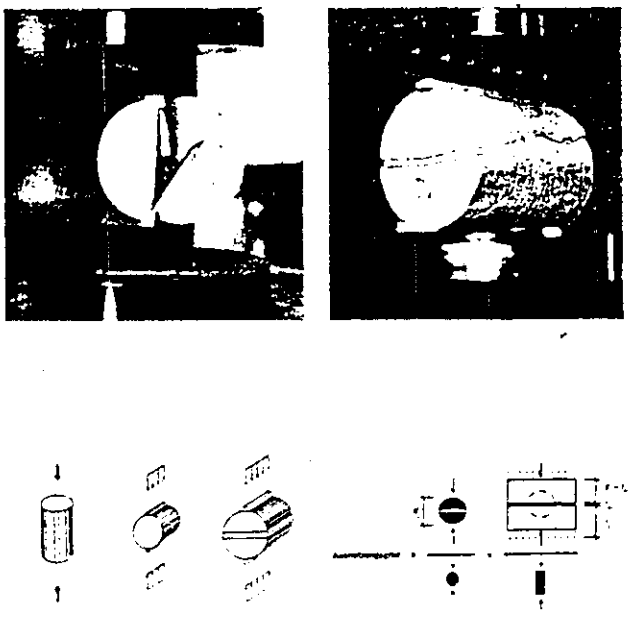


Fig 12: *Basic tests to determine the masonry compressive strength*
(a) Split cylinder test on stone
(b) Split cylinder test on bed joint cores
(c) The three basic tests
(d) Development of the formula

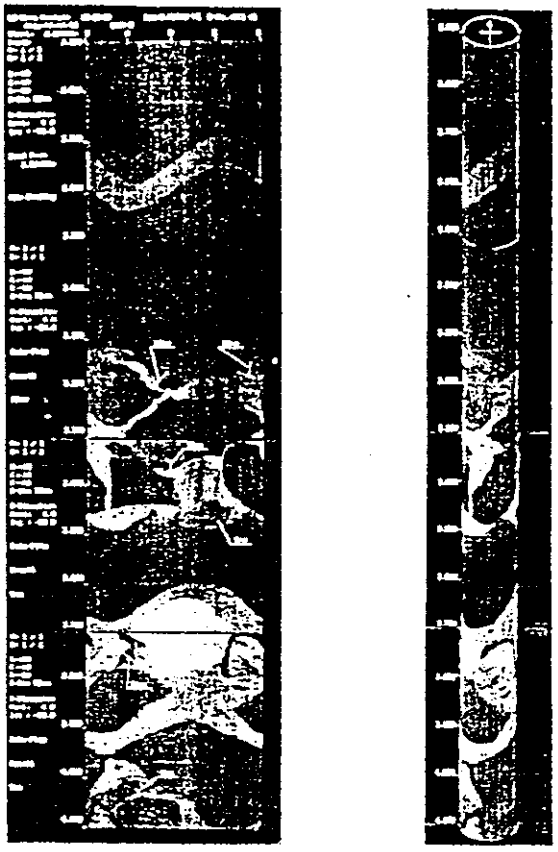


Fig 13: *Video Camera Survey of foundation masonry (Rossi 1997)*
(a) Lateral view of the surface of the borehole
(b) Reconstruction of the specimen by computer program

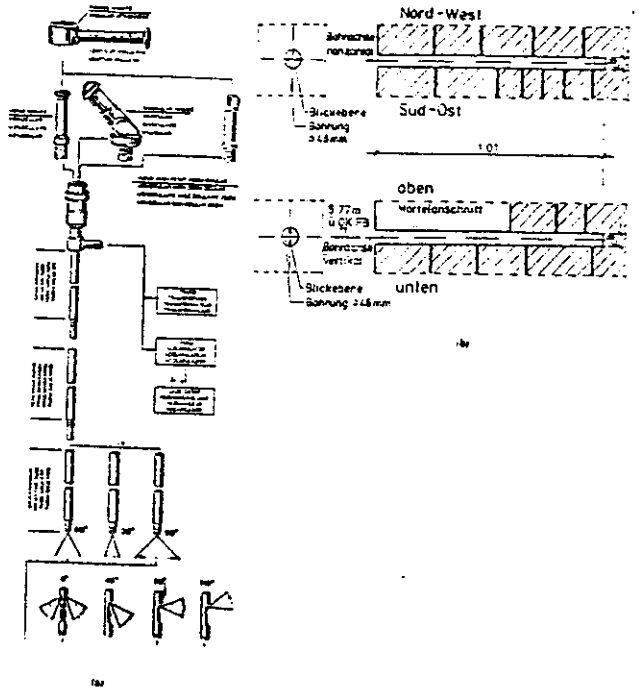


Fig 14: *Endoscope and results (Classen & Co., Hamburg; Birger Gigla, Karlsruhe University 1998)*
(a) Details of endoscope
(b) Construction of masonry details based on endoscope study

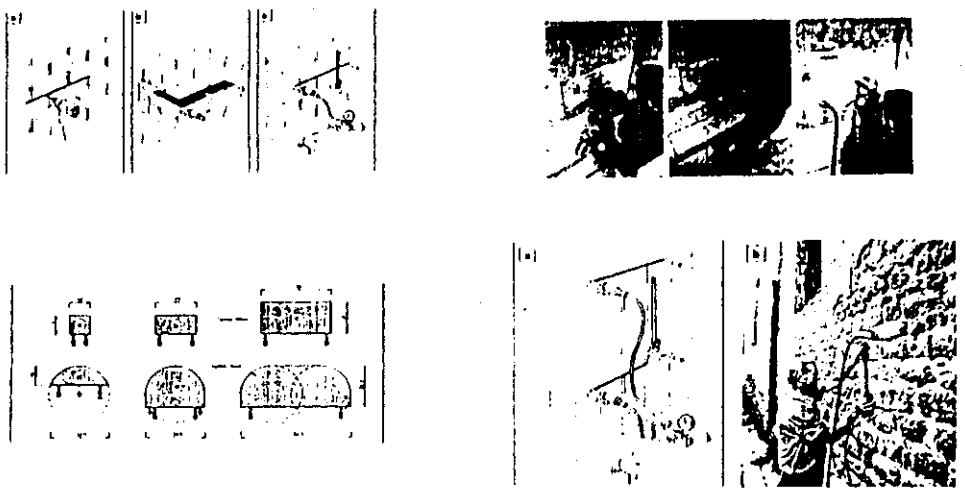


Fig 15: *Flat jacks (Rossi 1997)*

(a) Flat jack set-up on masonry wall for testing
(b) Drilling and insertion of flat jack
(c) Flat jack shapes (a,b,c for brick masonry, d,e,f, for stone masonry)
(d) Test set two flat jacks to determine deformability characteristics

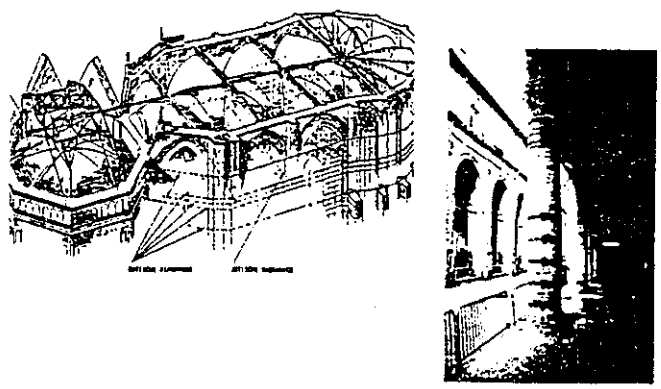


Fig 16: *Temporary Strengthening*
(a) Ring anchor around Aachen Cathedral (Ullrich 1989)
(b) Strengthening of column (Eckert 1997)
(c) Strengthening of a weak column in Maulbronn Monastry (Wenzel 1998)

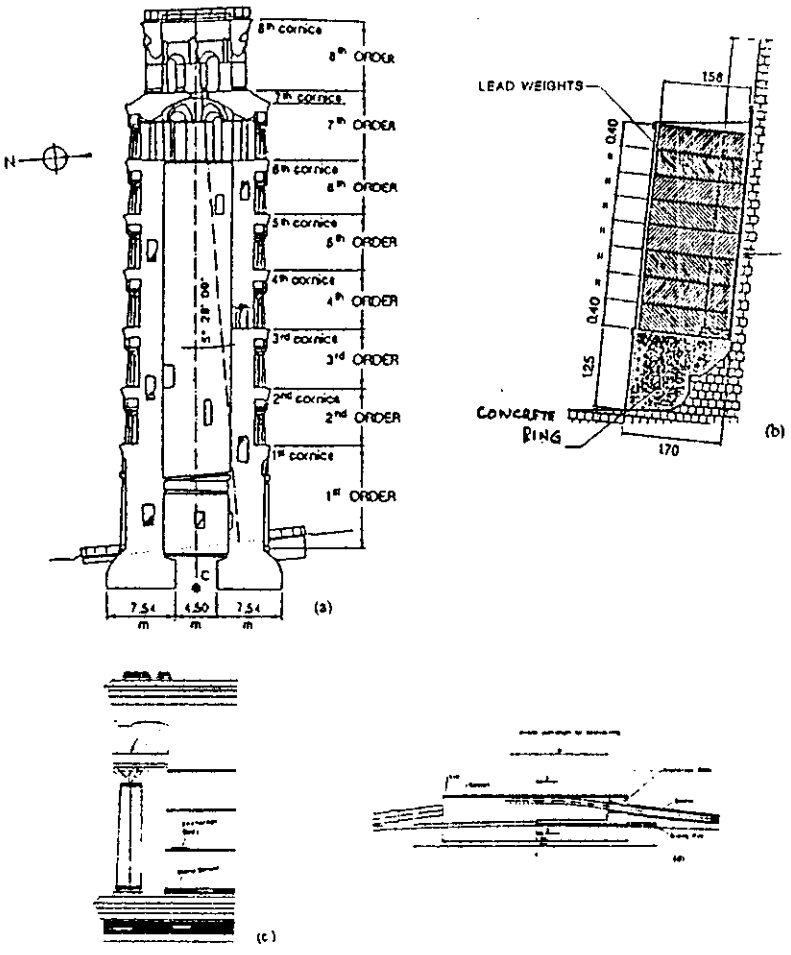


Fig 17: *The reversible interventions in the Tower of Pisa*

(a) The tower of Pisa
(b) Reversible prestressed concrete ring with lead weights on top of it
(c) Reversible prestressing at first loggia level
(d) Specially designed anchorage on a sliding pad

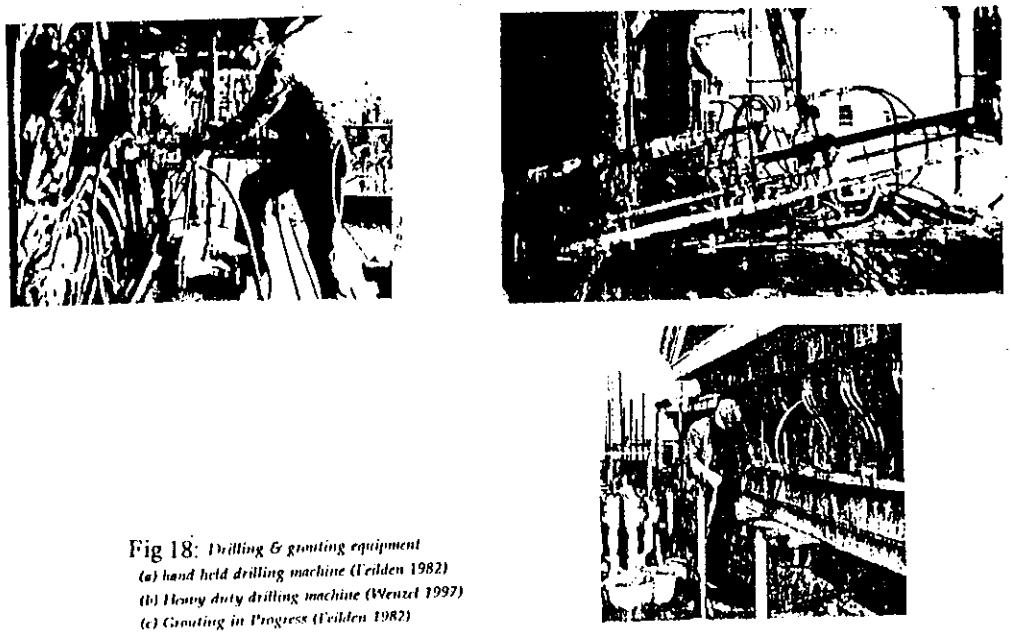


Fig 18: *Drilling & grouting equipment*
(a) hand held drilling machine (Veilden 1982)
(b) Heavy duty drilling machine (Wenzel 1997)
(c) Grouting in Progress (Veilden 1982)

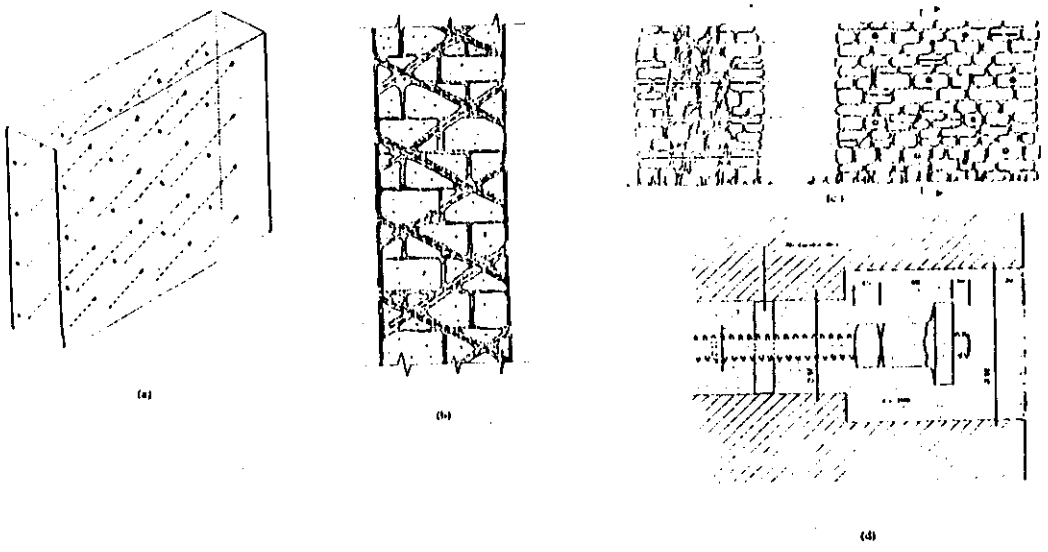


Fig 19: *Stitching (Lizzi 1981, Wenzel 1997)*

(a) Diagram showing diagonal cross stitching of masonry walls
(b) Cross-section of masonry wall showing diagonal stitching
(c) Grouting, stitching sequence
(d) Anchors for reinforcing bars to ensure bond

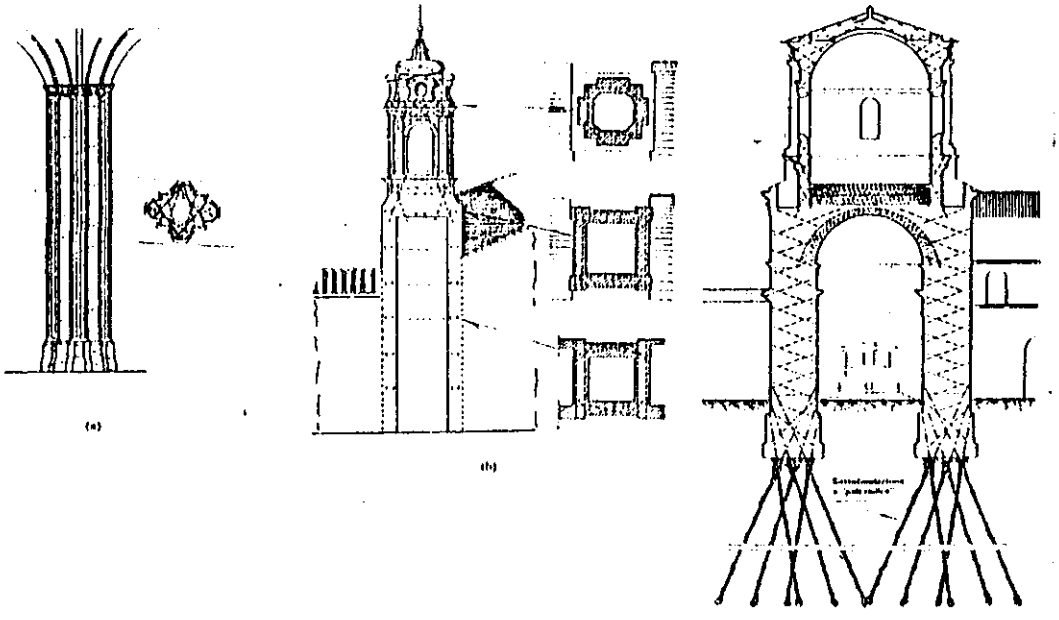


Fig 20: *Practical Examples of Stitching (Lizzi 1981)*

(a) Stitching of a historical column
(b) Stitching of the church of St. Marco in Italy
(c) Stitching and micropiling the Church of St. Andrea in Rome

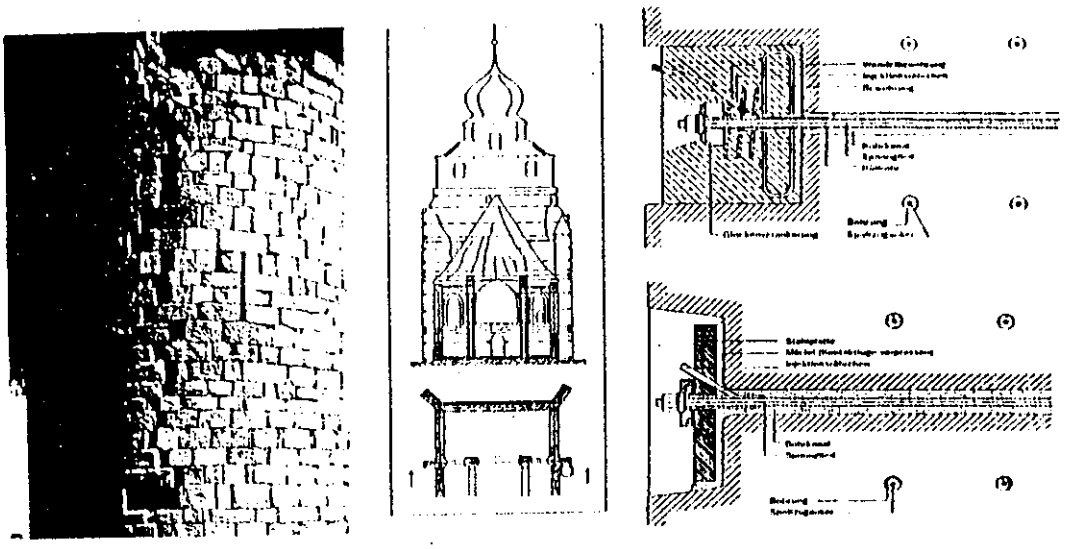


Fig 21: *Prestressing masonry walls (Eckert Wenzel 1997)*

(a) A severly torn wall
(b) Prestressing of Collegiate Church in Herrenberg, Germany
(c) Anchoring of prestressing rod with concrete anchors
(d) Anchoring of prestressing rod with Steel anchors

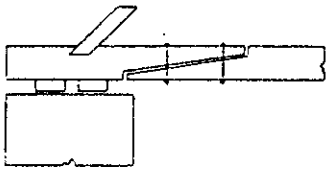


Fig 4.50: Scarf joint, only one line will be seen from below (Haller, Karlsruhe 1998)

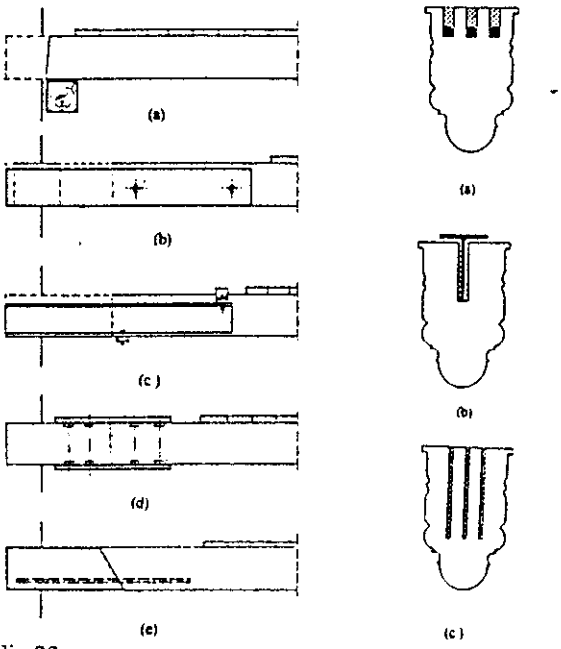


Fig 22: *Repair methods for timber beam ends*

(a) Support the beam end on a new beam
(b) Attach two timber pieces on both sides
(c) Attach steel channel sections on both sides
(d) Attach steel plates on top and bottom
(e) Resin repair (new portion is made of resin)

Cross-section of a articulated beam

(a) Steel rods glued with epoxy resin
(b) Steel and aluminium sections glued with epoxy resins
(c) Placing polymer composite insertions in specially made incisions

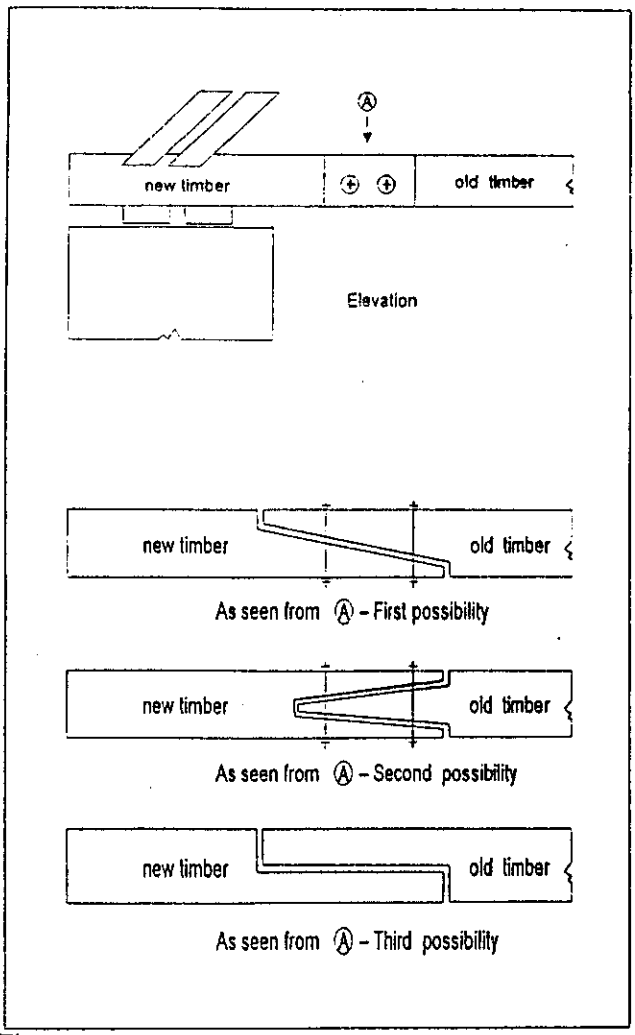


Fig 23: *Different Scarf Joints. (Haller, Karlsruhe 1998)*

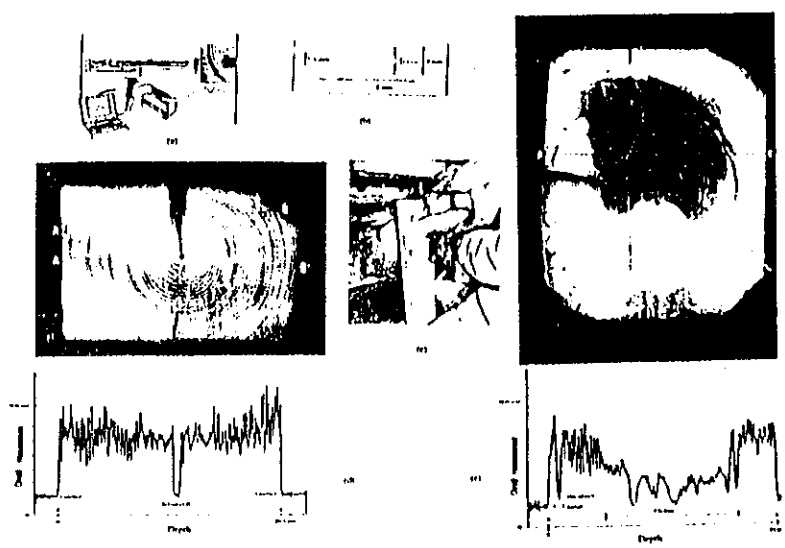
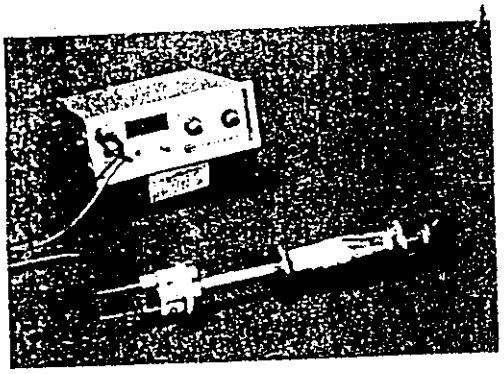
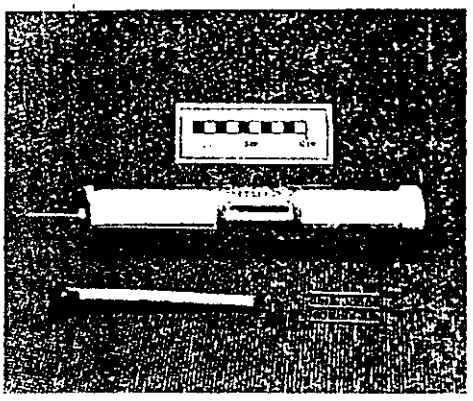


Fig 24: *Resistograph and results from Resistograph (Rinn 1993, Gerlacher 1996)*

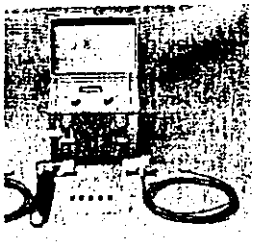
(a) Schematic view of Resistograph, drilling into timber, printer and computer
(b) Details of drill
(c) Details of Resistograph
(d) Resistograph diagram clearly showing crack in timber
(e) Resistograph diagram clearly showing decay in timber

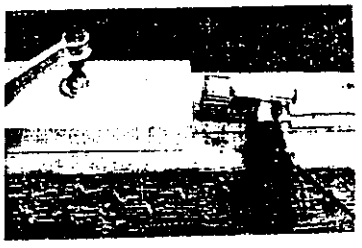


Wood
Moisture
Detection Meter



Wood
Testing Hammer
from Proceq S A





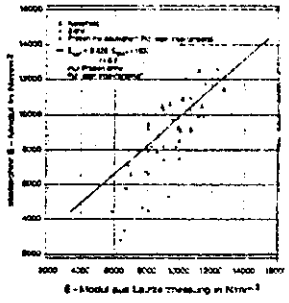


Fig 25: Stress wave timer (Gorlacher 1996)
(a) The measuring device, hammer and transducer
(b) Hammer ready to hit the end of a beam
(c) Correlation between static elastic modulus and stress wave elastic modulus

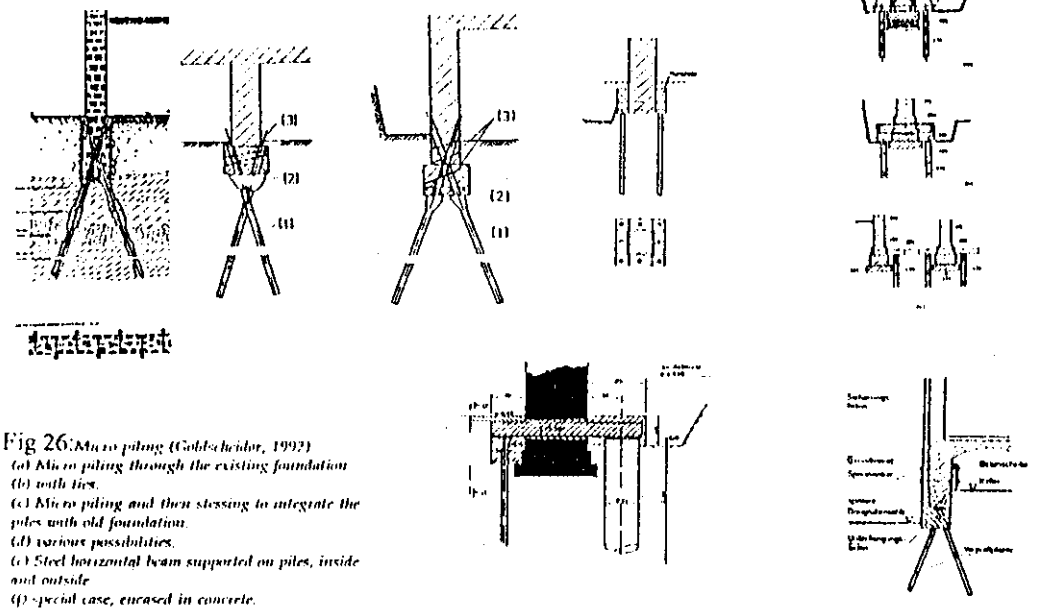


Fig 26: Micro piling (Goblirchidor, 1993)
(a) Micro piling through the existing foundation
(b) with ties.
(c) Micro piling and then stressing to integrate the piles with old foundation.
(d) various possibilities.
(e) Steel horizontal beam supported on piles, inside and outside
(f) special case, encased in concrete.

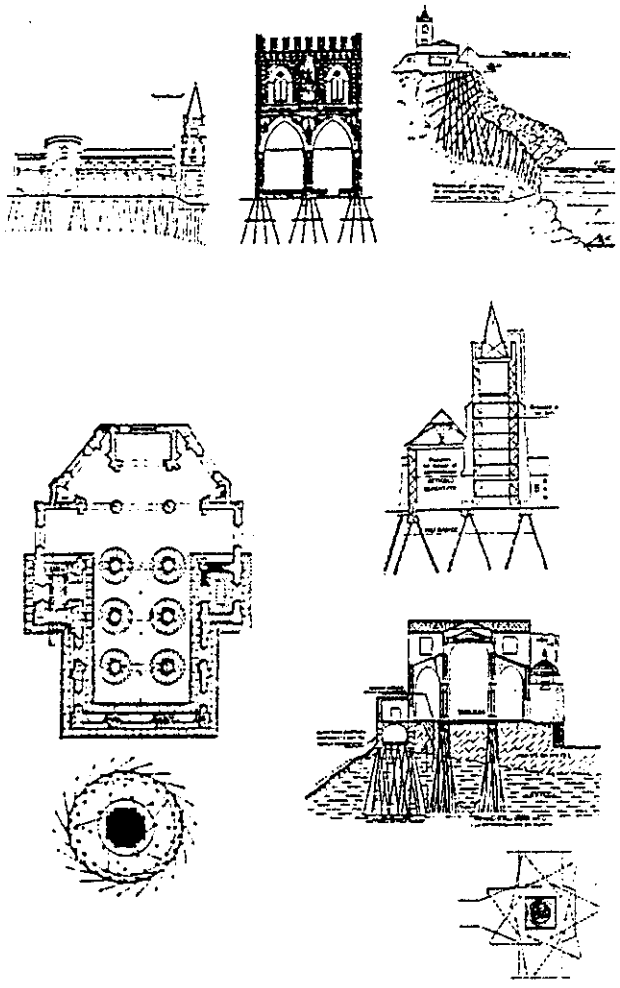
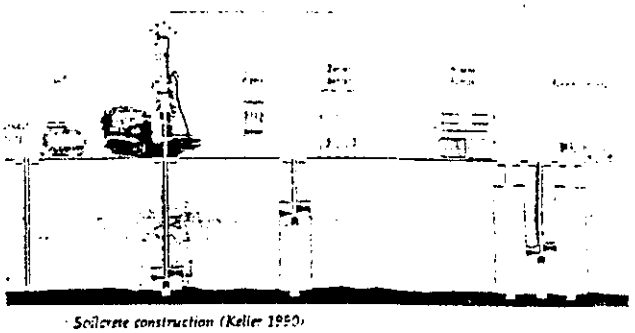


Fig 27: *Application of Micro-piling in historic buildings (Lizzi 1981)*



Soilcrete construction (Keller 1990)

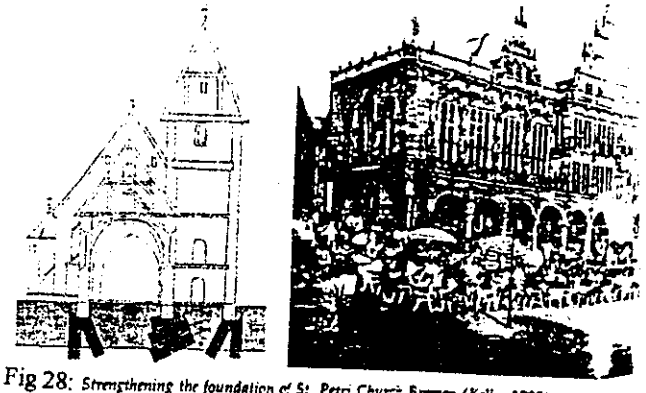


Fig 28: *Strengthening the foundation of St. Petri Church Bremen (Keller 1990)*
(a) Application of Soilcrete.
(b) General view of the church.

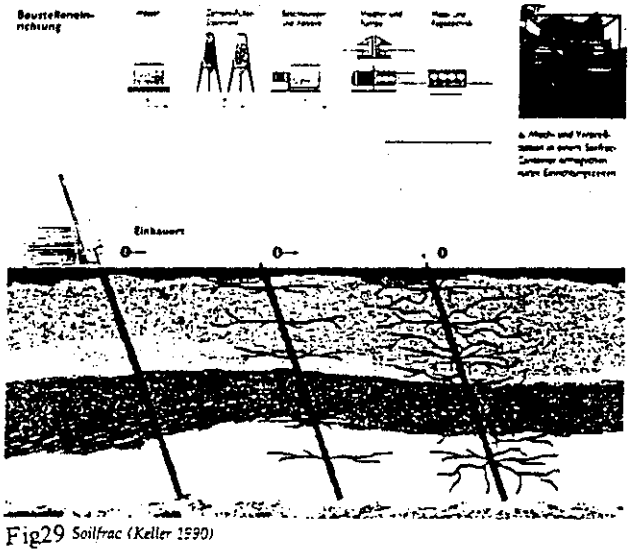
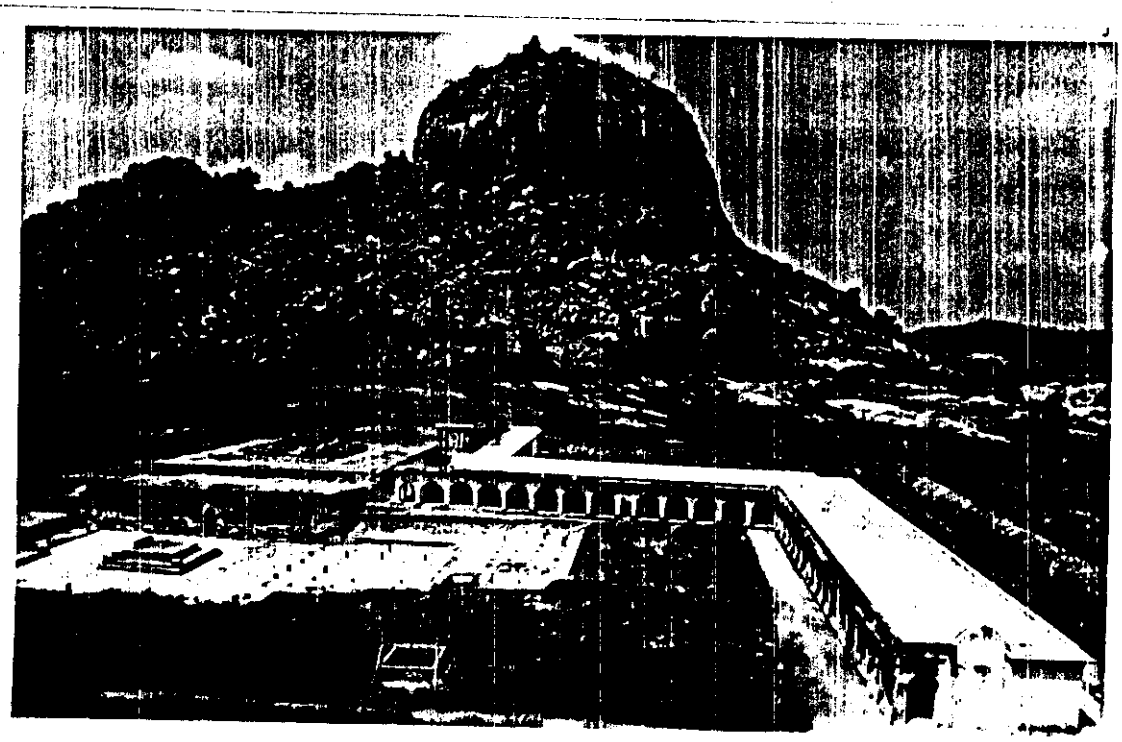
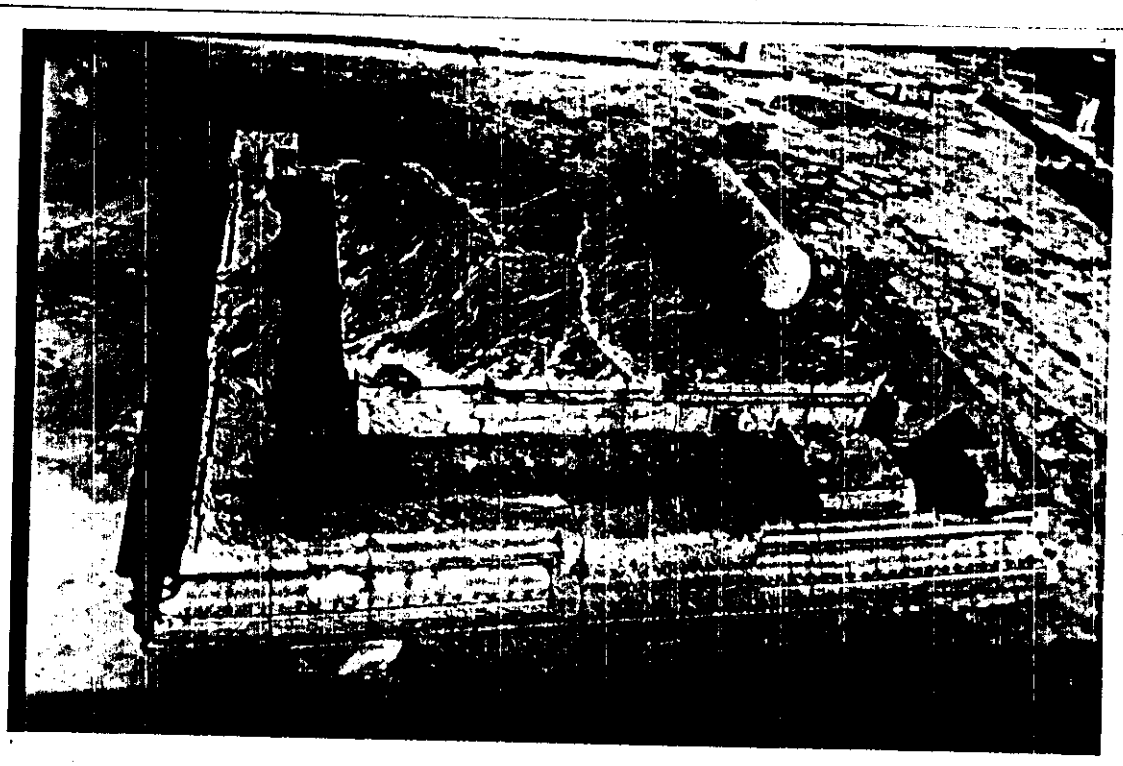


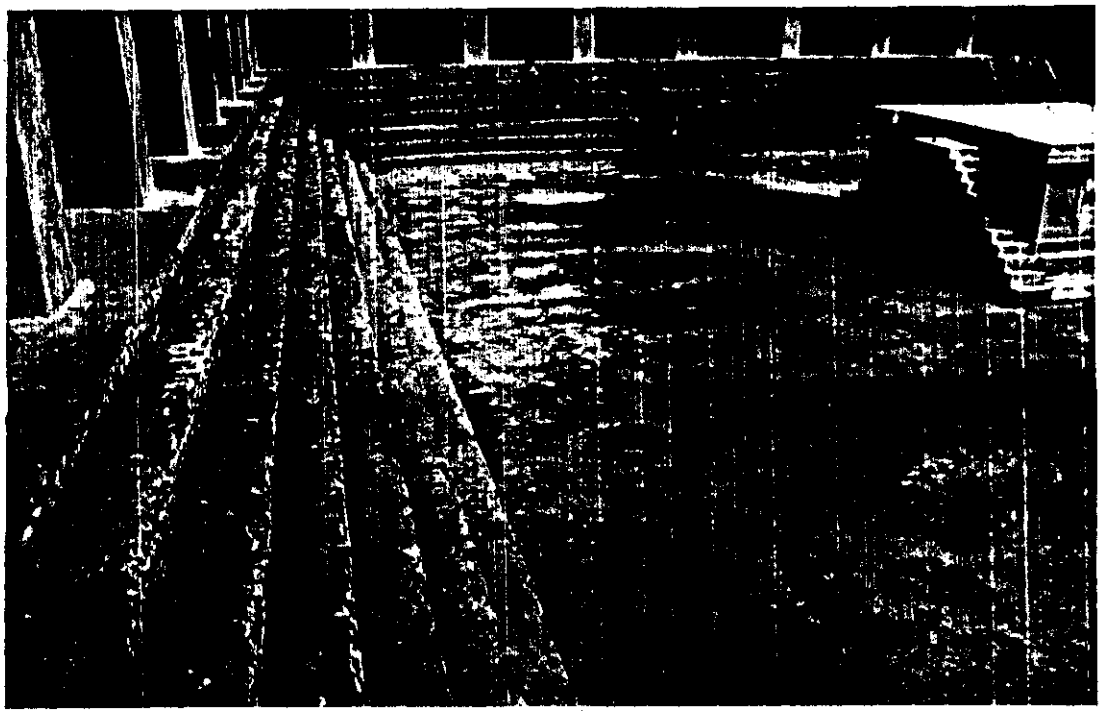
Fig29 *Soilfrac (Keller 1990)*



Open Darbar, Royal Throne at the
Centre at the back of Rajagiri
Fort, Ginjee

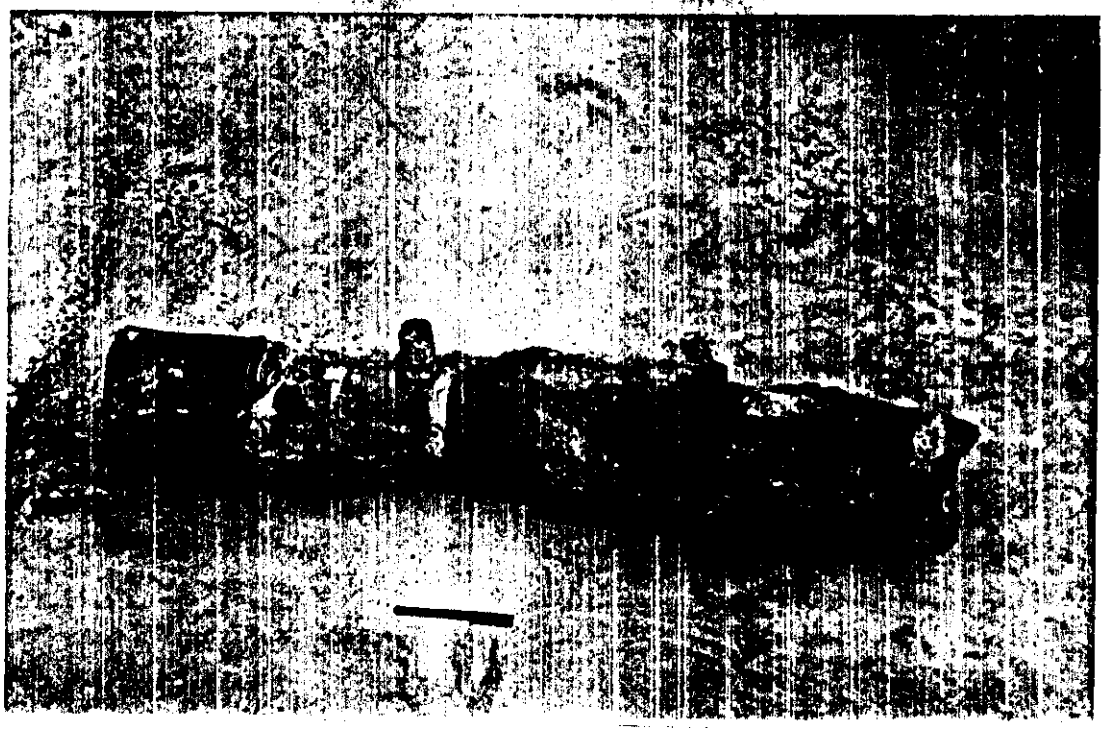


Royal Throne with back cushion
(close view) within Rajagiri Fort
at Gingee



Stepped Tank within Kalyana Mahal
at Gingee

Series of fountain nozzles made of terracotta
within Kalyana Mahal at Gingee



Piece of main terracotta water pipe
with two nozzles at Gingee

Terracotta pipe connecting nozzles with main
Pipe in the stepped tank within Kalyana Mahal
at Gingee