Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 70 (1993)

Rubrik: Session 1: General aspects

Session 1

General Aspects

Aspects généraux

Generelle Aspekte

Leere Seite
Blank page
Page vide

L'ingénieur et la sauvegarde du patrimoine monumental

Der Ingenieur und die Denkmalpflege

The Engineer and the Preservation of Architectural Heritage

Raymond LEMAIRE
Prof. émérite
Conserv. du Patrimoine
Heverlee, Belgium

RÉSUMÉ

L'essentiel pour le constructeur moderne est un édifice qui soit fonctionnel quant à son usage, rationnel quant à sa structure et la mise en oeuvre de ses matériaux, sûr pour ses utilisateurs et son environnement. L'objectif de la sauvegarde est la conservation de l'édifice quant à son message architectural propre, quant à l'authenticité historique de son message, quant au maintien de ses matériaux originaux; l'usage de l'édifice, la correction de sa structure, sa sécurité, sont souvent relégués en position subalterne. La collaboration des ingénieurs et des conservateurs est indispensable à la sauvegarde d'un édifice vieux de quelques siècles.

ZUSAMMENFASSUNG

Das Wesentlichste für den modernen Konstrukteur ist ein funktionstüchtiges, seinem Verwendungszweck entsprechendes Gebäude, rationell in seiner Auslegung und dem Einsatz von Baustoffen, sowie sicher was Benützer und Umfeld betreffen. Das Ziel der Denkmalpflege ist die Erhaltung des Gebäudes was seine eigentliche architektonische Botschaft, seinen historisch relevanten Ursprung und die Erhaltung der Originalbaustoffe angehen. Die Nutzung eines Gebäudes, seine Sanierung, seine Sicherheit werden oft in den Hintergrund gedrängt. Die Zusammenarbeit der Konservatoren mit dem Ingenieur ist unabdingbar für die Erhaltung eines jahrhunderte alten Gebäudes.

SUMMARY

From the point of view of the modern builder, the main aspects of a historical building are a functional serviceability, a rational structural concept and use of materials and a safe operation for users and environment. The objective of the preservation is a building keeping its original and authentic architectural message, including the original construction materials; the operation of the building, the rehabilitation of its structure, is often of limited interest. The cooperation of engineers and conservers is an absolute condition for the preservation of a building of some centuries of age.

"Ars sine scientia nihil est". Voilà le premier écho que nous renvoie l'histoire du conflit latent et fréquent entre architecte et ingénieur.

Cela se passait à Milan à la fin du XIVème siècle. Le "consilio fabricae ecclesiae Mediolani", incontestablement inquiet sur la compétence de leurs architectes chargés de la conception et de la construction de leur nouvelle cathédrale, décident de soumettre leur projet à des "maximi inzigneri", avertis de l'art gothique, qu'ils vont chercher au nord des Alpes. Il est vrai qu'à l'époque les architectes d'Italie n'avaient encore qu'une expérience limitée et plutôt provinciale de l'art nouveau et que le "nouvel oeuvre" de la capitale lombarde s'engageait sur de voies qui paraissaient hazardeuses. Les experts se succèdent à un rythme rapide : Nicolas de Bonaventure en 1389, trois ans après la mise en route des travaux, Annas de Fribourg, peu après, le célèbre Heinrich Parler, architecte de la cathédrale de Cologne et de l'église Sainte-Croix à Swäbisch-Gmünd en 1391, le tout aussi célèbre Ulrich von Ensingen, architecte en charge des cathédrales de Stasbourg et d'Ulm en 1394, trois experts français, parmi les quels Jean Mignot en 1399.
Les archives de l'"opera del Duomo" conservent une relation détaillée des discussions, pour le moins animées, entre les architectes locaux et les "maîtres" appellés à la rescousse. Le conflit est patent. Les locaux tiennent à leur oeuvre qu'ils considèrent parfaitement conçue mais qui inquiète leurs commanditaires. Les "nordiques" expriment des inquiètudes nombreuses autant en ce qui concerne la conception architecturale que la stabilité. Au jugement des "nordiques" les architectes locaux sont des ignares qui ne saisissent goutte à la "scientia" qui préside à la construction des cathédrales gothiques. Ils leurs concèdent une pratique de l'"ars", c'est-à-dire de la pratique de la construction, mais qui n'est guère adaptée à l'architecture nouvelle. Tous les avis des "ingegneri" sont refusés par leur collègues milanais. Aussi annoncent-ils unanimement la catastrophe, "magnum damnum ipsi fabricae pro suis malgestis", si les "locaux" poursuivent leur projet.

Le conflit est total : "ars sine scientia nihil est" leur lance Jean Mignot. "Scientia sine ars nihil est" répliquent les locaux.

Mais de quel "scientia" et de quel "ars" s'agit-il? L'"ars", nous l'avons vu, est celui de la bonne pratique constructive: des pierres bien appareillées, des remplissages de murs "à sacco" maçonnés correctement, des assises de pierres particulièrement sollicitées bien agrafées, etc... Cet "ars" appartient à tous les styles, à toutes les époques où l'art de construire est apprécié.

Qu'en est-il de la "scientia"? Il s'agit essentiellement de "scientia geometriae". Celle qui permait d'établir si l'élévation d'une cathédrale gothique doit se concevoir "ad triangulum" ou "ad quadratum", si le triangle doit être équilatéral ou Pytagoricien, celle qui gère la mise en forme et en proportion des éléménts d'architecture en respectant des rapports de dimension simple : double, triple, dont la justification scientifique est inexistante mais qui se réfèrent à la bonne pratique, à l'expérience et rejoint, de ce fait, davantage l'"ars" que la "scientia". C'est elle qui est l'objet des "secrets" que le maître transmet à ses disciples sur les chantiers des cathédrales.
Il est clair cependant, dans l'esprit des "ingegneri" de l'époque, que ces rapports géométriques ont aussi, et peut être même fondamentalement, une signification structurelle. Ils y attachent des normes de sécurité constructive déduite de l'expérience en l'absence, à leur époque, de toute base d' approche analytique des contraintes développées par les structures qu'ils conçoivent. Jean Mignot déduit que leur non observation pour la construction de la nouvelle cathédrale conduit nécessairement celle-ci à la ruine.

Paradoxalement les limites de vérité de cette "scientia" sont démontrées, au sein même de la cathédrale qui, bien que ne tenant aucun compte des théories "nordiques" ni des conseils insistants et des mises en garde des "maximi inzegneri" appelés en consultation, et donc entièrement conçue et construite selon les conceptions des architectes locaux, est toujours debout... Non sans quelques problèmes de stabilité cependant !

De tels conflits furent certainement plus fréquents que ne le rapportent les rares archives de chantiers qui sont parvenues jusqu'à nous. L'expérience et l'intuition basée sur l'analyse et le jugement apporté sur les réalisations antérieures étaient les seules vraies sources de connaissance. L'appel à des architectes extérieurs pour l'appréciation de travaux en cours était pratique courant à l'époque. On peut imaginer l'ampleur des discussions "inter doctores lapidum", la vigueur des mises en garde, l'admiration pour l'audace, aussi, que devait provoquer la construction d' oeuvres marquantes au plan de la structure tels que, parmi une multitude d'autres, le choeur des cathédrales de Beauvais ou de Tournai, la coupole de la cathédrale de Florence, la tour de la cathédrale de Strasbourg.

Peu, et en fait pas, d'écrits sur la théorie de la stabilité qui nous renseigne sur la structure du raisonnement, sur les méthodes d'évaluation des charges et des poussées. On ne peut les déduire que de l'analyse des édifices. N'oublions pas cependant que notre approche est nécessairement influencée par nos connaissances actuelles et que ce fait nous empêche, au moins partiellement de se mettre à la place des maîtres d'autrefois et de reconstituer la marche de leur raisonnement.

Certes, la connaissance du cadre "scientifique" de l'élaboration de leurs extraordinaires projets peut contribuer à une meilleure compréhension de leurs idées, mais là, aussi, nos sources sont pauvres. Les rares auquelles ont puisse recourir, et qui sont indiscutables parce qu'elles sont inclues dans des manuscrits d'architectes, tels que ceux de Villard de Honnecourt ou de Mathias Roriczer, sont, "in den freien kunst geometrien", d'un contenu tellement élémentaire qu'elles nous sont de peu de secours.

Il nous faut donc comprendre au seul vu de l'architecture telle qu'elle se présente à nous. Mais est-ce regrettable ? Ne disposons-nous pas de moyens d'investigation qui nous permettent de concevoir ce qui se passa "de facto" au sein des structures anciennes et nous permettent, de ce fait, d'affronter leur consolidation éventuelle avec succès ?

Beaucoup d'entre nous sont certainement d'accord pour juger une telle affirmation avec une pointe de scepticisme, voire même d'ironie. Certes nous avons progressé considérablement dans l'affinement de nos méthodes d'analyse structurelle et de calculs de stabilité et nous pouvons approcher de plus près la réalité des contraintes qui se développent au sein des grandes structures construites par nos prédécesseurs, mais combien, de grands monuments auquels les calculs refusent l'existence et qui font cependant l'admiration des foules depuis des siècles.

Combien sont-ils, en effet, de monuments célèbres qu'une application, même très mesurée, de nos normes de sécurité condamneraient à la démolition? L'intuition, enracinée dans le riche humus de l'expérience, qui inspirait les grands architectes d'autrefois approche-t-elle la réalité de l'équilibre structurel que nos calculs sophistiqués ?

Cette constatation nous conduit à une approche modeste des chefs-d'oeuvre d'autrefois. Et c'est dans la modestie que doivent se situer les interventions des architectes et des ingénieurs sur les monuments historiques.

Quelques grands principes doivent rappelés ici pour situer ces interventions et en définir les limites éthiques.

Le conflit fréquent entre l'architecte conservateur de monument historique et l'ingénieur relève, en général, tout autant de l'éthique que de la technique.

Dès leur formation, leurs objectifs sont différents. L'ingénieur est appelé à concevoir, à constuire ou à assurer la stabilité des édifices et des structures rationnelles par rapport aux connaissances actuelles de toutes les disciplines qui interviennent dans la construction. La fonctionalité, l'équilibre et la sécurité sont les exigences fondamentales et premières de ses oeuvres. Aucune autre valeur ne prend le pas sur celles-là.

Le conservateur se trouve, lui, devant des bâtiments existants avec leurs spécificités, leurs qualités et leurs défauts. Si leur équilibre et leur sécurité sont importantes, ce ne sont pas, pour lui, les valeurs primaires. De même, si leur usage est souhaitable et constitue, en général, un facteur favorable à sa bonne conservation, cet aspect de l'édifice n'est pas son souci capital. Ce qui ne signifie pas qu'il les considère comme des données négligeables. Toutefois, l'essentiel réside dans la nécessité de conserver l'oeuvre du passé à la fois dans ses valeurs esthétiques -l'oeuvre d'art- que de préserver les traces de son passé -l'histoire- dont il est porteur. Tâche difficile et délicate car combien de fois n'y a-t-il contradiction entre ces deux objectifs, les traces de l'histoire oblitérant ou effaçant des aspects essentiels de l'oeuvre d'art ou vice-versa. Pour lui, la fonction de l'édifice devra s'adapter à la manière d'être du bàtiment ancien et des marques de son passé, et non le contraire. Si l'instabilité d'une construction ancienne l'inquiète, il s'oposera à sa démolition ou à son démontage et attendra de l'ingénieur qu'il fasse des "pirouettes" techniques, si nécessaire, pour maintenir la structure existante.

On le voit, les priorités des valeurs, les systèmes de raisonnement des deux disciplines sont étrangères l'une à l'autre, parfois même radicalement divergentes ou même opposées.
Il ressort de ce qui précède que, défendues dans toute leur rigueur, les deux disciplines sont souvent difficiles à concilier. La volonté de conserver est souvent rivale de celle d'assurer la sécurité. Et on le comprend car, fréquemment, ce sont des productions essentielles du génie créatif de l'homme qui sont en cause. Quel ingénieur oserait assurer, professionnellement, que le choeur de la cathédrale de Beauvais est sans danger? Ou que le campanile de Pise ne s'écroulera pas? Personne n'avait prévu la chute de celui de Venise en 1902 ou celle, plus proche de nous, de la tour de Pavie en 1989. Mais, par ailleurs, quel ingénieur aurait osé proposer leur démolition pour cause d'insécurité?

Le conflit est souvent dramatique car il oppose, au sein du jugement des mêmes personnes, des valeurs auxquelles elle ne peut être insensible professionnellement d'une part, de par sa culture ou son sens des responsabilités d'autre part. Si l'ingénieur conclut au danger que constitue pour les usagers, les visiteurs, les voisins ou les passants l'instabilité d'un monument historique et que la logique de son métier conclut à la nécéssaire démolition, généralement sa culture s'opposera à une telle mesure destructrice d'un témoignage artistique, historique ou symbolique de l'histoire des hommes. Le conservateur se trouve face au même conflit mais inversé : si le devoir de préserver s'impose à lui de façon impérieuse, l'importance des dangers que cette obligation comporte ne lui échappe pas.

Les données même du conflit, qui comporte à la fois une dimension professionnelle et morale, doivent orienter la recherche d'un nécessaire terrain d'entente. Il est évident que l'analyse des problèmes qui requièrent l'attention des deux parties sous le seul angle professionnel de chacune d'entre elles n'ouvre aucune perspective pour la sauvegarde d'un patrimoine qui a besoin de la compétence et des meilleurs soins spécifiques de l'une et de l'autre.

Il s'agit pour chacune de prêter l'attention requise aux problèmes et aux valeurs de la partie adverse. Cela présuppose que chaque partie ait une connaissance ou au moins une compréhension suffisante de l'ensemble des problèmes posés par la sauvegarde du monument en cause. Une formation post-universitaire adéquate vise précisément à assurer celle-ci à toutes les partie intervenant dans la préservation du patrimoine monumental.

Toutefois au-delà de la perception juste des problèmes seule la référence à des principes fondamentaux peut orienter la recherche de la solution adéquate dans les situation difficiles. Ces principes sont à la base de la "Charte de Venise, 1964" qui, malgré ses trentes ans d'âge, constitue encore, au plan mondial, le "cathéchisme" de la conservation et de la restauration des monuments et des ensembles historiques.

Le premier principe est celui de l'unicité du monument historique. Un monument n'a qu'une "vie". Un monument détruit ne peut être reproduit chargé de toutes ses valeurs. Certes on peut en faire une réplique qui en reproduit les formes, mais celle-ci ne pourra transmettre qu'une partie des messages dont l'original était chargé. La conservation de cet original constitue donc l'essence même de la conservation. Toute solution qui contredit à ce principe nie le but même de l'objectif recherché : transmettre aux générations futures le patrimoine culturel, chargé d'art et d'histoire, que constitue les monuments et ensembles historiques.

La deuxième valeur fondamentale qui doit sous-tendre toute décision valable est le respect de l'authenticité du monument. Il s'agit d'un concept complexe dont certains aspects demandent encore à être clarifiés et précisés.

L'authentidité du monument peut être envisagée sous un double aspect : l'authenticité de l'oeuvre d'art et celle du document d'histoire.
Il est évident que toute intervention sur un monument historique doit préserver l'intégralité du message artistique qu'il contient. Nous nous trouvons là face à l'essentiel du message. Le problème, qui parait simple dans l'approche théorique, est, en fait, généralement beaucoup plus complexe dans la réalité quotidienne. Beaucoup de monuments ont subi au cours de leur longue et parfois dramatique histoire des transformations et des altération, du fait des hommes ou de la nature, qui ont atteint plus ou moins gravement leur message artistique original. Alors de quel message artistique s'agit-il lorsqu'il faut prendre position face aux différentes options d'intervention possibles? Autrefois, on hésitais peu : le rétablissement de la situation originale, ou celle que l'on pouvait supposer telle par comparaison avec des édifices similaires ou apparentés, était l'option la plus courante. Les nombreuses erreurs auxquelles ont conduit cette conception et les transformations dramatiques et irrécupérables qui en furent les conséquences nous ont appris à nous méfier de ce mode d'intervention. L'abstention en situation de doute ou, en cas de besoin, le complément neuf qui tout en s'intégrant esthétiquement et s'exprimant avec modestie, rèvéle la sensibilité et le langage artistique de notre temps paraît, aujourd'hui, une option préférable.

Le second aspect de l'authenticité concerne celui de la vérité, et donc de la crèdibilité, du témoignage historique. On s'accorde sur le fait que le patrimoine monumental constitue une source essentielle de connaissance du passé. Des civilisations entières, disparues aujourd'hui, ne nous sont connues que par les ruines de leur constructions, celles de l'Amérique prècolombienne par exemple. Par ailleurs, les vestiges monumentaux du passé nous en apprennent souvent beaucoup plus, et d'une manière plus exacte, que les sources écrites. Une visite aux Pyramides n'est-elle pas plus fructueuse pour l'appréciation de la civilisation pharaonique que la description, cependant minutieuse et admirative que nous en donne Hérodote? Et une simple description contemporaine de la construction du choeur de la cathédrale de Beauvais, de la coupole de Sainte-Sophie à Constantinople ou de celle de Sainte-Marie-des-Fleurs à Florence nous permettrait-elle, en leur absence, d'en imaginer l'incroyable audace constructive? Il n'y a pas d'histoire en l'absence de sources crédibles. Etant donné l'importance, en la matière, du patrimoine monumental, il est évident que toute intervention doit être respectueuse de cette valeur. Toute destruction de substance historique est un peu d'humanité, héritée de nos ancêtres, qui disparait, appauvrissant inéluctablement le patrimoine humain du présent et du futur.

De l'autre côté de l'approche des problèmes de la sauvegarde du patrimoine, celle du conservateur et de l'historien, la pleine perception et le respect d'autres valeurs : e.a. la nécessaire sécurité et la possibilité d'un usage adéquat des édifices doivent être évalués à leur juste importance. Généralement les monuments se trouvent dans un environnement que fréquentent les hommes. La plupart remplissent encore des fonctions essentielles dans la société. Il est donc évident que leur approche ou leur usage ne peut constituer un danger permanent pour leurs usagers. Cela comporte des exigences qui sont souvent opposées à la sauvegarde de la substance originale d'un batiment : des parties instables doivent être refaites; des pierres altérées deviennent dangeureuses et pourraient tomber : elles doivent être remplacées par de nouvelles qui ne sont que des copies. Ainsi se rétrécit, comme une peau de chagrin, la substance originale seule porteuse de l'intégralité du message artistique et historique.
De même, l'expérience apprend tous les jours que, quelque soit leur valeur, seuls les monuments qui remplissent une fonction reconnue utile à la société ont une chance d'être entretenus convenablement. Cet usage n'est souvent pas sans effets pervers sur la sauvegarde de vestiges ou d'états d'une réelle valeur historique. Ce n'est pas sans sacrifices d'un coté que d'autres avantages, plus importants au niveau de la conservation fondamentale, peuvent être obtenus.

Résoudre des situations conflictuelles, chercher la meilleure voie entre des intérets ou des besoins opposés : voilà la tache difficile et délicate à laquelle ingénieurs, architectes, historiens et historiens d'art sont attelés. Elle ne peut atteindre son but : assurer l'avenir du riche patrimoine monumental légué à notre génération qui a le strict devoir de le transmettre intégralement aux générations suivantes, sans que tous les intervenants ne s'accordent sur les valeurs essentielles qu'il s'agit de préserver. Aucun intervenant n'a sur d'autres de priorité de principe. Tous sont au service de la même cause et doivent investir leur connaissances, leur imagination, leur expérience dans la recherche des solutions qui préservent le mieux toutes les valeurs du monument dont ils ont la charge.

Il est incontestable que les ingénieurs partent dans cette collaboration interdisciplinaire avec un handicap certain : leur intérêt pour le patrimoine historique est plutôt récent. Aurait-on imaginé un congrès comme celui-ci il y a dix ou vingt années ?

Une difficulté majeure provient du fait que depuis trois quart de siècle, c'est-à-dire plusieurs générations d'ingénieurs, les matériaux de construction essentiels, le béton et l'acier, ont ouvert des voies nouvelles à la construction et à l'architecture. Les méthodes d'analyse et de calcul ont été développées quasi exclusivement en fonction des nouveaux moyens de construction. On a négligé l'étude, avec les moyens d'investigation de la science contemporaine, des structures et des matériaux traditionnels. On a assez systématiquement suprimé l'enseignement de l'histoire de l'architecture des programmes de formation, parfois même des architectes, ou on les a rèduit à une portion infime.

Ce n'est que depuis quelques années que l'on observe un intérêt renouvelé pour l'application aux monuments anciens des instruments d'analyse et de quantification de la science moderne de l'ingénieur. On s'est apperçu, alors, que les méthodes d'analyse et de calcul utilisés couramment pour les constructions modernes n'étaient guère applicables aux structures traditionnelles et qu'il fallait rechercher des voies nouvelles. Certes les lois de la mécanique et de l'équilibre sont les mêmes pour tous et à toutes les époques. Toutefois les moyens de les analyser et de quantifier les contraintes peuvent être fort divergentes. Les constructions anciennes, parfois d'une extrême complexité, telle une cathédrale gothique ou une coupole de Guarini, ne se laissent pas analyser correctement avec les méthodes de calcul classiques. Par ailleurs, les matériaux anciens, et plus particulièrement les liants traditionnels à base de chaux tombés hors d'usage, ont été peu étudiés et sont encore mal connus, surtout en ce qui concerne leurs propriétés mécaniques et leur évolution sur les temps longs. Or ce sont eux qui régissent principalement la solidité des maçonneries anciennes. Que vaudraient nos méthodes de calcul de stabilité, appliquées aux constructions contemporaines, si nous n'avions qu'une connaissance superficielle du ciment et de l'acier ?
De même, nos moyens d'investigation physique des constructions anciennes sont encore élémentaires, tout au moins en ce qui concerne les conclusions qu'on peut en déduire.
L'ingénieur approche, donc, le terrain spécifique de son intervention dans la conservation et la restauration des monuments anciens avec le handicap d'une connaissance encore bien imparfaite du domaine dans lequel un diagnostic difficile et exact est cependant essentiel et les interventions presque toujours d'une grande délicatesse. Et ses moyens d'investigation crédibles encore souvent peu développés ou adaptés à la nature des problémes. Hélas, il ne s'en rend pas toujours compte et ses limites ne lui sont pas toujours apparentes. La modestie est toujours une bonne disposition de l'esprit lorsqu'on aborde l'analyse d'un monument ancien et une sérieuse connaissance historique de son contexte indispensable. Tout comme son concepteur, l'architecte et l'ingénieur chargés de la restauration d'un monument historique doivent, "volens nolens", aborder les problèmes avec une bonne dose d'intuition !

Que conclure ?

Tout d'abord constater la fonction capitale de l'ingènieur dans la sauvegarde du patrimoine monumental. Notre société n'admet plus de vivre dans un environnement bâti dont la sécurité ne serait plus assurée. Elle n'a plus, à cet égard, le fatalisme des générations passées. Elle veut avoir, en la matière, des assurances que seul l'ingénieur et, dans une moindre mesure, l'architecte sont à même de lui fournir.

Une deuxième conclusion doit constater la non préparation de la plupart des ingénieurs à cette tâche. Les programmes universitaires ne les y préparent guère et le danger est donc grand qu'ils s'y aventurent avec un bagage scientifique et une expérience inadaptés voire insuffisants. Donc, la formation spécialialisée au niveau post-universitaire leur est un complément indispensable. Elle est encore trop exceptionnelle aujourd'hui. Son cadre normal doit être celui d'un programme interdisciplinaire, le seul qui permet de garantir, dès le niveau des études, une approche dans laquelle tous les aspects des problèmes posés par la sauvegarde d'un monument sont analysés et évalués à leur juste place et mesure et procure l'expérience vécue de l'indispensable collaboration avec les tenants des autres disciplines concernées.

La troisième conclusion concerne l'absolue nécessité de la recherche. Il est indispensable et urgent d'approfondir nos connaissances des structures anciennes, des matériaux traditionnels, de leurs modes de mise en oeuvre. Il est tout aussi nécessaire de mettre au point des méthodes d'investigation et de calcul mieux adaptées aux manières traditionnelles de construire. Un champ d'investigation vaste et peu exploré qui ne peut, lui aussi, n'être abordé fructueusement que grâce à une approche interdisciplinaire.

Structural Aspects in Restoring Monuments

Aspects structuraux dans la restauration des monuments

Strukturelle Aspekte in der Denkmalpflege

Giorgio CROCI
Prof.
Univ. 'La Sapienza'
Rome, Italy

G. Croci, born 1936, has carried out important research, studies and projects for the strengthening and restoration of historical buildings. The Colosseum and Palace Senatorio in Rome, the Ducal Palaces in Modena and Genoa, the Castle of Spoleto, the Basilicas of St. Francis in Assisi and St. Ignacio de Loyola in Spain, represent some examples of his activity.

SUMMARY

This lecture highlights the different domains where structural engineering can contribute to the knowledge and restoration of Architectural Heritage. The assessment of the actual safety level of the monument is needed to decide on necessary measures. Objective and subjective aspects have to be taken into account. Whenever measures are needed, the advantages and disadvantages of the use of new or old materials and techniques are evaluated. The convenience of reversibility is examined. Finally, possible codes will be discussed to avoid misuse of existing codes which are not suited for this kind of structures.

RÉSUMÉ

Cet exposé traite des différents domaines où le génie civil peut apporter sa contribution à la connaissance et à la restauration du patrimoine architectural. La détermination de l'état de sécurité du monument permet de décider des mesures à prendre. Dans les cas où les interventions sont nécessaires, les avantages et les désavantages de l'usage de matériaux nouveaux ou anciens et les techniques correspondantes sont examinés. La réversibilité doit être prise en compte. La possibilité est envisagée de créer une norme afin d'éviter l'application de normes existantes mais inadéquates pour ce genre de structure.

ZUSAMMENFASSUNG

Es werden verschiedene Gebiete aufgezeigt, in denen der konstruktive Ingenieurbau wesentliches zur Denkmalpflege leisten kann. Die momentane Bestandesaufnahme ist notwendig, um über allfällige Interventionsmassnahmen zu entscheiden. Objektive und subjektive Aspekte sind zu berücksichtigen. Bei notwendigen Eingriffen werden die Vor- und Nachteile der Verwendung neuer oder alter Baustoffe und -techniken erwogen. Die Rückgängigmachung wird untersucht. Schliesslich werden Normen diskutiert, die den Einsatz heutiger, jedoch für derartige Konstruktionen ungeeigneten Normen verhindern sollen.

1. INTRODUCTION

The contribution of structural engineering in the study and design of restoration has been very important in the last few decades; from new investigation instruments to the most sophisticated monitoring networks, from information systems to mathematical models, from special devices for use on site to new technology and techniques for repairs. However the result of this large back-up has been only partially successful due to the unmethodical and often casual advances at the forefront of progress, the lack of interdisciplinary vision and insufficient cultural awareness; the result has been investigations seldom inserted within a coherent global program, the illusion of understanding the real behaviour on the basis of mathematical models which were not completely reliable, interventions carried out using new technology and materials that were not only insufficiently tested to simmulate the real conditions and thus ensure durability, but that also deeply altered the original conception.

Thus the time appears to be ripe for a general critical review of all matter and to face the main problems that can be reduced to two points:

- how to evaluate the safety levels of a monument and consequently how to decide whether or not interventions are needed;

- how to identify the criteria of interventions and the appropriate technology to use, taking account of the double requirement to alter as little as possible the original conception and to ensure safety and durability.

2. THE JUDGEMENT OF SAFETY LEVELS OF A MONUMENT

2.1

The evaluation of the bearing capacity, or more generally speaking of the safety levels, must be referred to three different conditions:

a) The Past. It is often useful to evaluate the safety levels of the original situation in order to understand if it was adequate at the time and if only subsequent deterioration or unexpected phenomena (earthquakes, soil settlements etc..) caused damage and failure. This evaluation helps us to find what the specific cause was. For example, in the case of the dome of St. Ignatius of Loyola in Spain, the structural analysis of the original "designed" form shows an irrational in the dome's shape, which is too hemispherical with a very heavy lantern on top; this causes high circumferencial stresses which generated the meridian cracks that are visible today. Although in the case of the St. Charles cathedral in Rome the crack pattern was similar, it was found, by means of a mathematical model, that as the shape was higher (figure 1), the dead loads could not have produced the cracks, not even taking into account thermal effects and seismic actions (in particular the strong earthquake of 1703). Further and deeper analysis, the observation of the cracks on the drum and the deformations of the cornice have shown that ancient soil deformations have been the determining factor; a monitoring system has shown that the deformations are now stabilized.

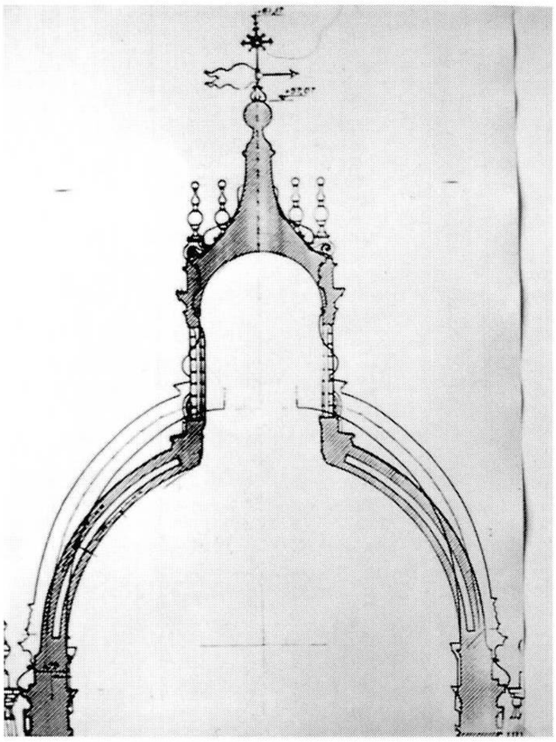


Fig. 1 Comparison between the shapes of St.Ignatius and St.Charles domes

b) The Present. The assessment of the present situation is the prerequisite for every intervention decision. In the above-mentioned dome of St. Ignatius, taking account of the cracks along the meridians, the analysis has shown large bending moments in the meridian arches, that result from the loss of circumferential continuity, and hence significant tensile stresses; thus we were obliged to develop a more sophisticated non-linear analysis that showed that only part of the section is in

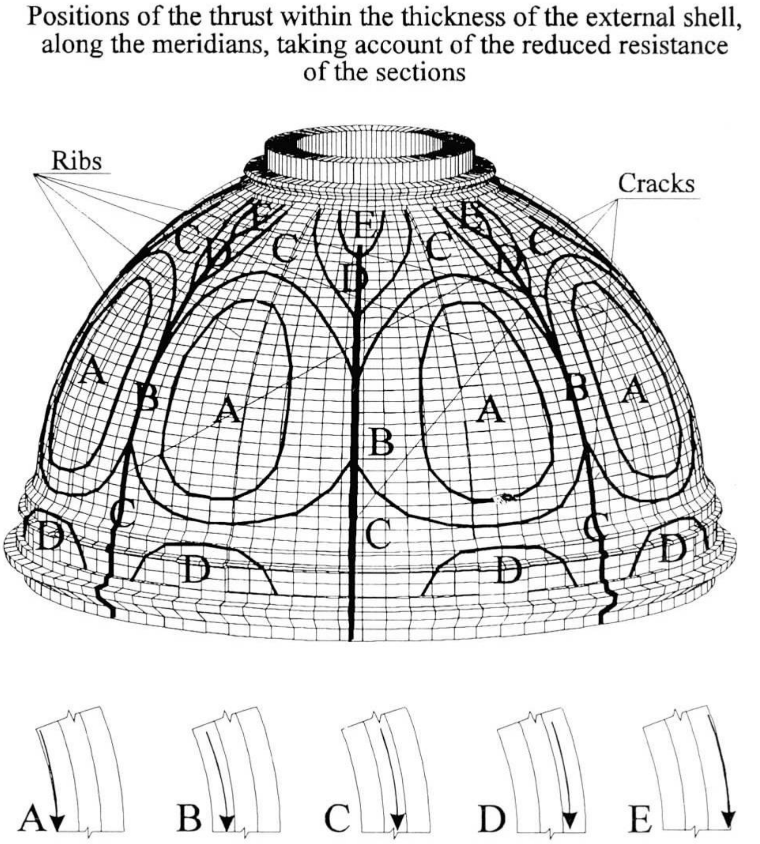


Fig. 2 St.Ignatius dome, cracks distribution and the results from a non-linear mathematical model

compression and that the safety levels are inadequate (figure 2).

c) The Future. The evaluation of the safety levels corresponding to various possible interventions gives not only a measure of the improvement of the behaviour, but also helps in the choice of the most appropriate criteria. In the Loyola dome it was easy to establish that prestressed circumferential cables are able to provide the radial pressure necessary to substantially compress the meridian section (figure 3).

2.2

The safety evaluation, however, is a very different task and cannot, unfortunately, always be obtained following mathematical analysis; on the contrary, this possibility is limited to very few simple cases. As a rule the process of arriving at a judgement is very complex and is acheived by an interlacing of objective and subjective aspects. There are three main routes to follow:

a) Observation of the reality. This process, which we may call the "empirical-qualitive method", lies in the survey of the monument as it stands today, through the observation of the quality of the materials, the crack and failure patterns, the foundation system, the ground morphology, etc.; this knowledge can be supported by chemical and mechanical tests and by data recorded on a monitoring system in order to highlight the evolution of various phenomena (figure 4).

The knowledge related to this process is linked to a subjective interpretation of the reality and is based on the comparison between what is now observed and what we have observed in the past in other constructions. From a philosophical point of view, this kind of knowledge can be included in the "inductive process category" upon which the observation of a great number of structures, failures and phenomena can lead to generalizations and thus, by means of synthesis, to a progressive enlargement of the knowledge itself, whose base is in experience. It was following this process that ancient builders were able to realize the great works of the past.

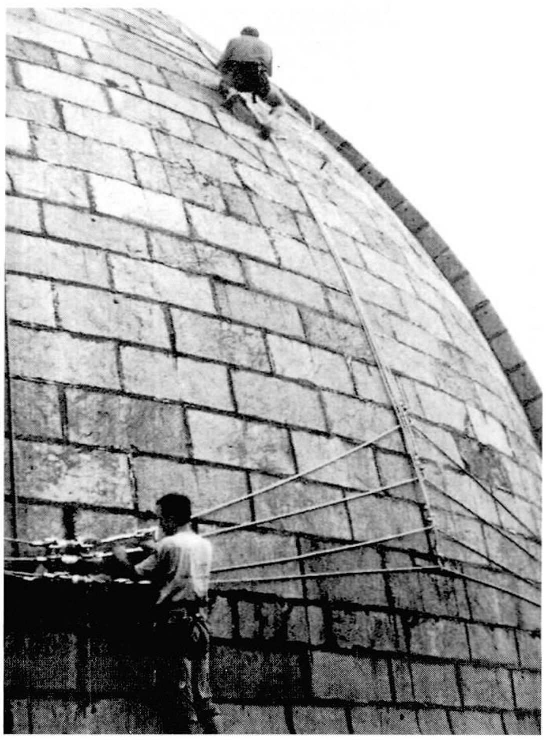
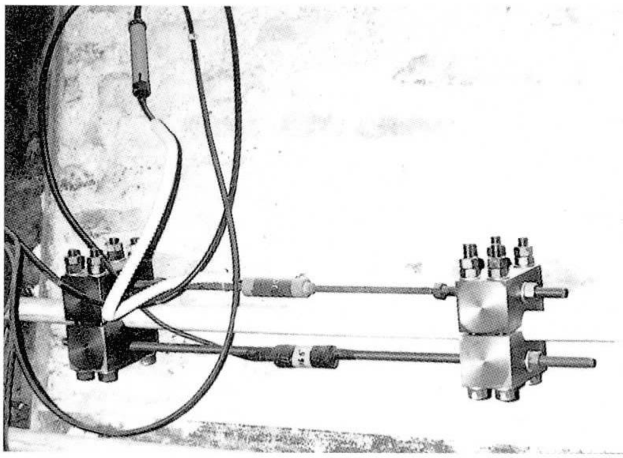
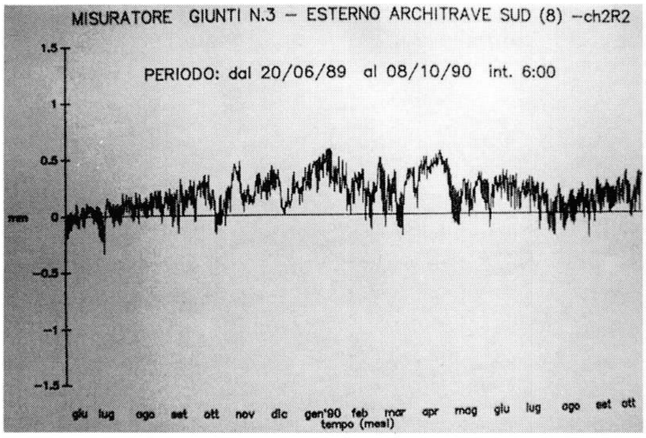


Fig. 3 Prestressed stainless steel circumferential cables



a)

b)



c)

Fig. 4 Monitoring system in the Loyola Basilica represented by: a network of instruments (a), a computer for data recording (b), results displayed in a time dependant diagram (c)

b) Mathematical Analysis. This process, which we can call the "theoretical-quantitive method", is usually based on the evaluation of the stress levels and deforfamations corresponding to different kinds of action (dead and live loads, temperature, soil settlements, earthquakes ....). In order to understand better the validity of this criteria, that from a philosophical point of view can be included in the "deductive process category", we must focus on the necessary compromise between a careful representation of the reality and the simplifications that are required to use the theories we have at our disposal.

This problem has represented a central point in the philosophy and in every cognitive process, in metaphysics as well as in epistemology: the possibility of connecting the subject with the object, the activity proceeding from the mind of man with real phenomena. From the conceptual point of view an important step has been realised by the the doctrine of "schematism" elaborated by Emanuel Kant in the "Critique of Pure Reason"; in his theory he attempts to overcome this apparent incomunicability by introducing an intermediate abstract element, the "scheme", which is accessible to the subject and representative of the object. In epistemology schematism is posed as a problem of scientific models, which are not only logical and mathematical constructions but also representations or imaginary pictures (i.e. schemes) of extremely complex structures. The scheme is located between theory and reality and is thus the only element capable of giving conceptual order and logical rigour to scientific knowledge.

c) Historical Survey. Last but not least this process is indispensable for a real knowledge of a monument. History provides an experimental laboratory on a real scale that we have yet to discover and decode by research, review and interpretation of historical documents, writings, drawings, photographs etc..

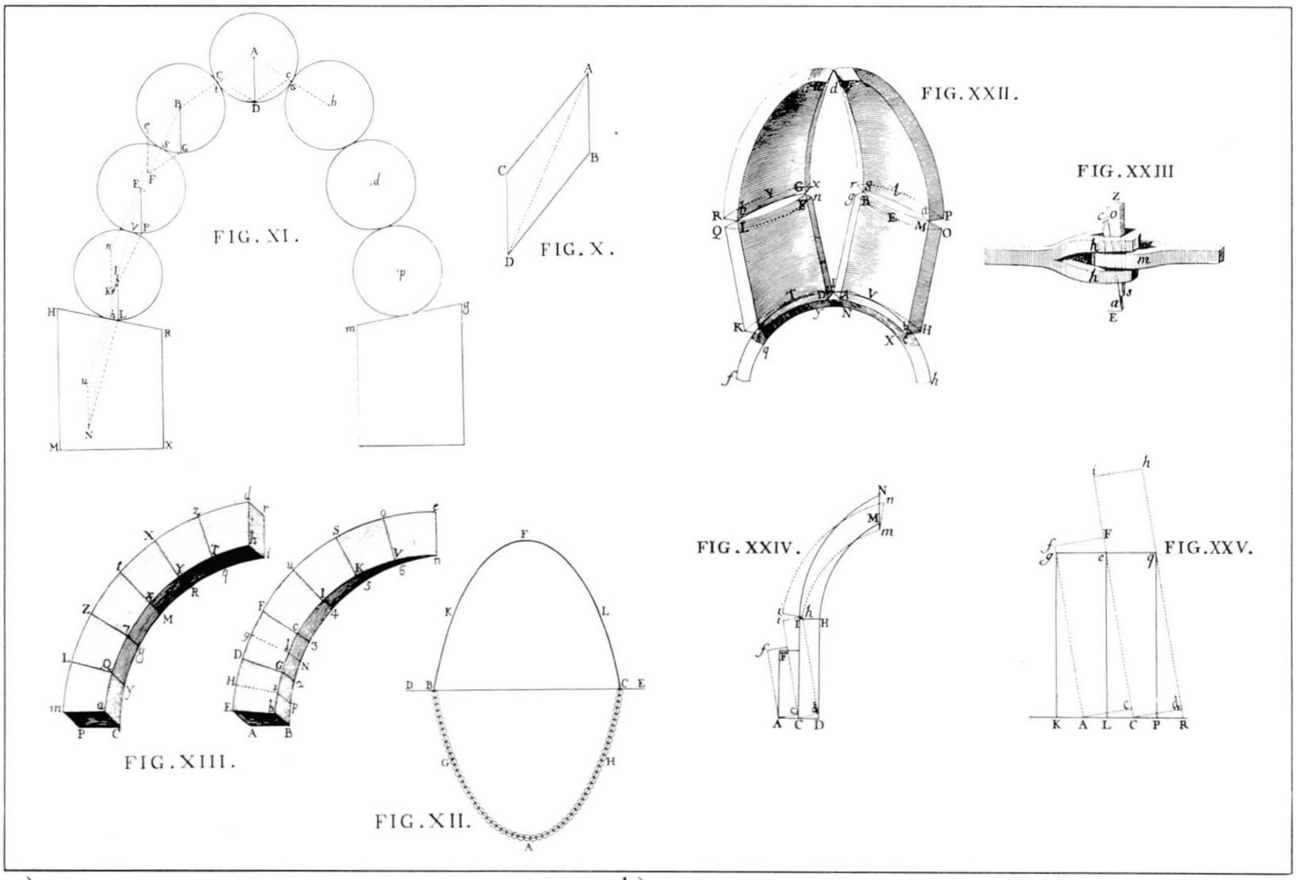
The main difficulty is that history was not written for structural engineering purposes and thus the objectivity of the facts must be partially rebuilt through the subjective reinterpretation of the researcher.

2.3

Thus each one of the three criteria we have mentioned contains both subjective and objective aspects. The perfect scheme is the reality itself; unfortunately we do not have objective mathematical theories to analyse it, so that only the subjective evaluation of an expert eye can give us a reliable approximation of the phenomena, and thus simplified schemes: the objectivity of the calculations do not provide objectivity in the knowledge.

Therefore we must acknowledge that mathematical models only furnish a support to the understanding, and not the understanding itself; the objectivity of the theoretical analysis is only apparant, as the choice of scheme is subjective and we know and accept that it provides a limited representation of the reality. Stresses higher than the resistance may not mean that the structure is unsafe, just as stresses lower than the resistance may not mean that the structure is safe; This limitation does not have solely negative aspects as it obliges engineers to overcome the boundary of theories and to enlarge their culture and the meaning of rationality itself; as Gaston Bachelard writes in "Le Rationalisme Applique": a knowledge of the non-rigorous must be restored so that a full comprehension of the rigorous may be possible.

This attitude tends to eliminate any argument between the supporters of the "theoretical" and "empirical" approaches that has continued throughout the centuries. One of the first disputes of this kind took place in 1742 when Pope Benedict XIV asked the opinion of "three Neopolitan Mathematicians" on the damages found of the dome of St. Peter's. The method they followed, that in a certain way sanctioned the official entry of science and mathematics into a field previously dominated by practice and experience, was extremely interesting: instead of using polygons of forces, they applied a primitive principle of virtual work to the dome, reduced to a rough mechanism, the cracks being likened to joints or hinges (figure 5). The results showed that the existing conditions did not ensure equilibrium and immediately became points of discussions; critics from among the



a) b)

Fig. 5 Structural analysis of St.Peter's dome from Poleni's "Historical Records of the Great Dome of the Temple" - Vatican 1748: a) theory of the curve of thrust, b) application of the principle of virtual work followers of the "empirical" approach responded "Michelangelo did not know mathematics but was still able to design the dome". However it is now time to lay aside sterile argument and to acknowledge that the value and reliability of the judgement, that simultaneously contains objective, subjective, quantative and qualitve aspects lies in the logic, rationality and the synthesis of the information available from the different processes, that is, experimental and theoretical analysis, historical survey and direct observation of the reality: a wider intergration of science and intuition, which Pascal called "l'esprit geometrique" and "l'esprit de finesse".

2.4

The impossibility to provide the "safety level" in the quantitative terms which structural engineering currently uses (limit state method etc..) poses new important problems, first of all the necessity of highlighting the different approximations involved in the study, that is to apply to the judgement an indication of the "reliability" of the judgement itself. Besides, if the "reliability" is low, we have to indicate if the approximations of the schemes and the simplified hypotheses have been made on the side of "prudence". This aspect is important because if a severe judgement leads to over-dimensioned interventions, but at the same time it has a low level reliability and we have been very prudent in the choice of scheme that determines the connections, restraints etc., we have to review the judgement itself and, if possible, to reduce the uncertainties by deeper analysis, investigations, etc..

Deeper investigations and stronger interventions can therefore be alternative options and we can decide the best route to follow on the basis of a general cost - benefit analysis.

In the case of the Colosseum, for example, it was the historical research which highlighted the role of earthquakes in the collapses; elastic finite element analysis, although "prudent", described extensively the initial behaviour and indicated the presence of the relevant tensile zones; the direct observation showed important permanent deformation and out-of-plumb, definitely related to earthquakes. It has been the synthesis of the information allowed us to first hypothesyse and then to verify that the process of the collapses has been progressive in two different ways: firstly during the main earthquakes of 443, 801, 1349 and 1703, that although of similar magnitudes found the monument in weaker and weaker configurations; secondly, "spontaneously" over the centuries with increasing rate as the cracks and the deformed structure facilitated and accelerated the deterioration. To try to follow all this by mathematical models in more "reliable" way, taking into account non-linearity, second order effects, residual stresses corresponding to permanent deformations, energy dissipation due to sliding of the blocks during an earthquake, differential soil settlements and seismic amplifications, linked to the heterogeneity of the foundations, that affect one part of the structure with respect to the other, is not possible; in any case, it would be extremely complicated and time consuming. Following these types of analyses can be the object of studies and research but not a realistic approach for ordinary engineers.

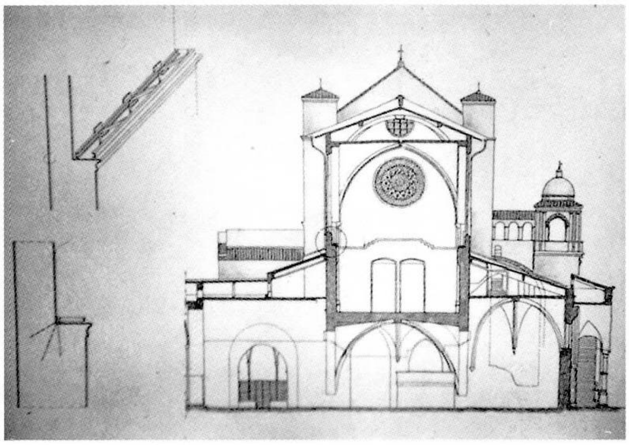
3. CRITERIA AND TECHNOLOGY FOR INTERVENTIONS

The decision of interventions and the time limit for their realization (each structure can be in a safe condition for a very short period of time and at risk for a very long period), is the consequence of the judgement on the safety of the monument. Some points must now be analysed:

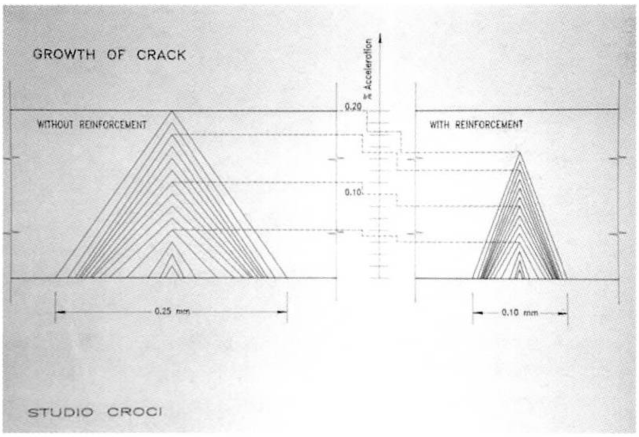
a) - Historical Value and Risks. Monuments are precious objects that must be respected and altered as little as possible; this statement can lead, however, to some contradictions as higher risks must sometimes accepted, to avoid or limit modifications to the original conception. These risks depend on the one hand, on the minimum level of interventions, that related to the incertitude of the safety judgement, can become insufficient, and on the other hand on a delay of the decision in order to carry out deeper and deeper investigations. The case of the leaning tower of Pisa belongs to this category; although long since declared a building at high risk, until now it has not been acceptable to intervene on the foundations, where, with the available modern technology, the problem could definitely be solved. This possibility is the final option following only after more detailed studies and investigations show that the regulation of the water table and/or other soil improvements are not sufficient. But paradoxically, this respect of the historical value delay the solution of the problem and the tower is currently left in high risk without provisional shoring.

b) - Reversibility. Nowadays the cultural trend is for interventions to be reversible, that is to allow for the possibility of their removal. In principle this philosophy is correct, taking account of the fact that judgements are not always sufficiently reliable and it therefore seems useful to allow for the possibility of applying better techniques and materials that will become available. This kind of philosophy has been proposed in the restoration of the basilica of St. Francis in Assisi, where it was revealed that earthquake forces, and in particular the component normal to the lateral walls, created cracks in the walls which support the Giotto frescos. Reinforcement has been designed in order to limit deformability and thus the damages that periodically affects the frescos; this reinforcement consists of a steel trussed beam placed over the cornice. The restraints between the steel beam and the walls are realized by oleodynamic devices so that relative movements are allowed under normal conditions, but the restaints become rigid, and thus effective, under dynamic actions (figure 6).

a)



b)



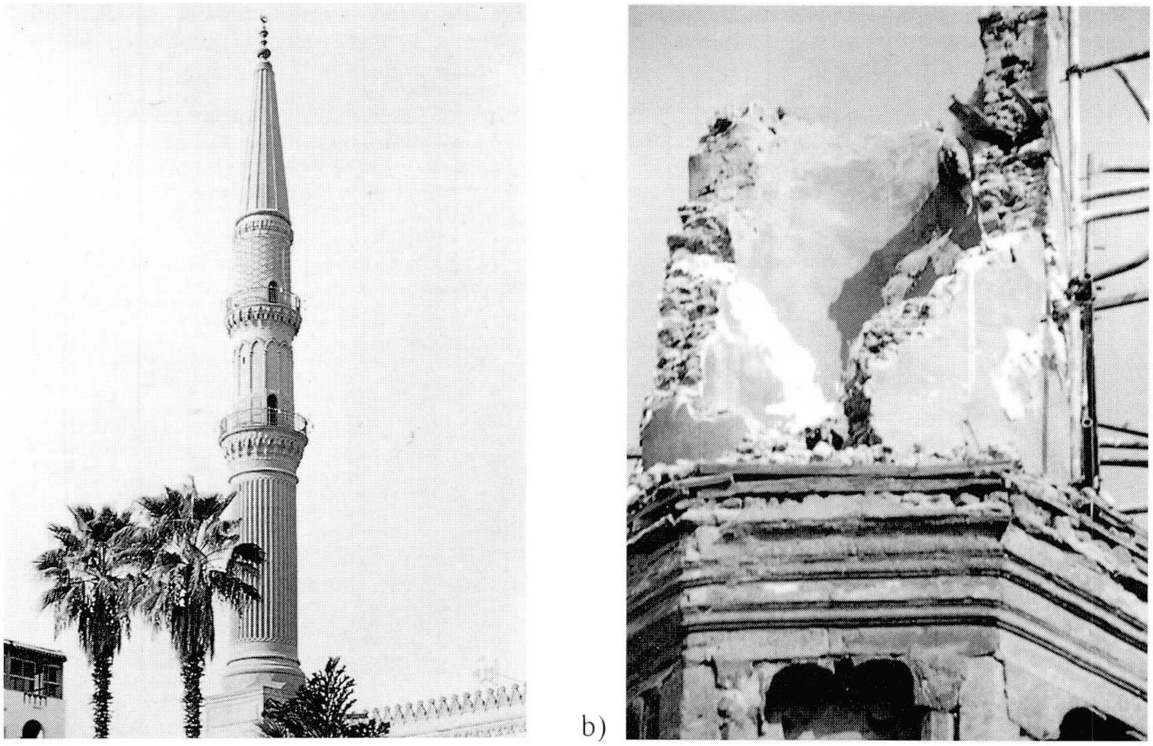
c)

Fig. 6 The Basilica of St.Francis of Assisi: a) vertical cracks that affect the walls, b) position of steel trussed beams over the intermediate cornice, c) reduction of the aperture of the cracks following the intervention

Another "reversible" intervention has been proposed for the reinforcement of some leaning minarets in Cairo, where six prestressed vertical cables will be placed along the interior perimeter, only creating small holes to cross the steps (figure 7).

It is important to note, however, that this philosophy must be accepted as a guideline rather than a compulsory method: situations where reversibility is neither possible or convenient are not infrequent, as, for example, the reinforcements of floors, the connections between walls and the strengthening of deteriorated masonry with appropriate grout injections.

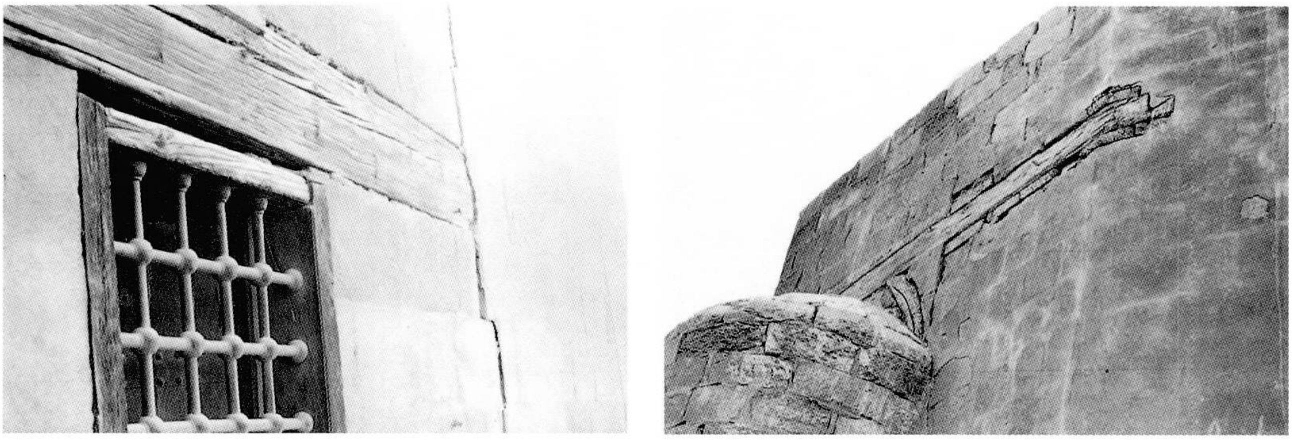
c) - Ancient Technology. This can contain much more wisdom than appears from a superficial analysis: the deformability of the masonry, increased by microcracks or small cracks, that do not compromise the stability, but allow adaptation to minor soil settlements; the exceptional bearing capacity of arches, vaults and domes, if the thrust can be contained; the intelligent use of wood, not only in floors and roofs, but also as ties to improve the continuity and connections in the walls (figure 8). The use of old materials and technology in restoration projects is therefore not only appropriate for retaining the historical value, but also as an admission of their validity and worth of



a) b)

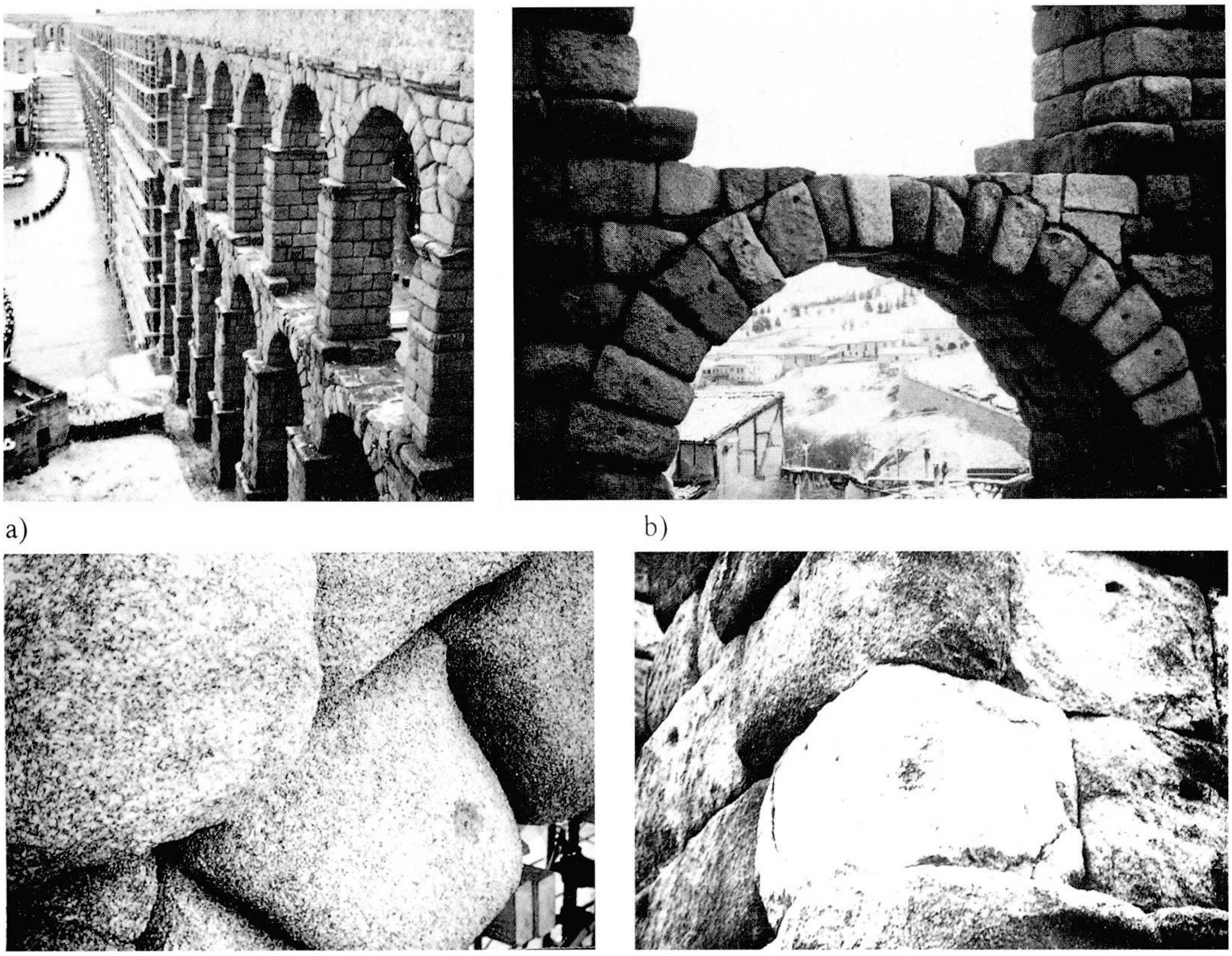
Fig. 7 Minarets in Cairo: weakness (a) and slenderness (b), often worsened by out-of-plomb

the original concept. In many cases it is just the passing of time and/or the anthropic activity that produce natural deterioration, whose rate has recently increased due to changes in enviromental conditions such as pollution, traffic, increases in population, etc.. The two thousand year old aquaduct of Segovia is still structurale sound and the real problems have been recently created by the traffic pollution (figure 9); the granite blocks, superposed without mortar allow small adjustments for the redistribution of stresses and do not contrast the thermal deformations. Restoration works must never change this behaviour and it will be necessary to reorganize the traffic in the downtown to radically solve the problem. The more than four thousand year old Chefren Pyramid (figure 10) only suffers from the consequences of a very slow but continuous eolic erosion, fortunately in dry conditions; the fall of some blocks during the earthquake of October 1992 is only the result of a lack of maintenance; it will not be necessary to use especially strong structures to fix the blockwork, but it will be sufficient to recreate the connections using the original materials and techniques, that have so successfully defied the millenia.



a) b)

Fig. 8 Wood chains to connect the walls (a) and to counteract the thrust at the base of a dome (b)



a) b) c) d)

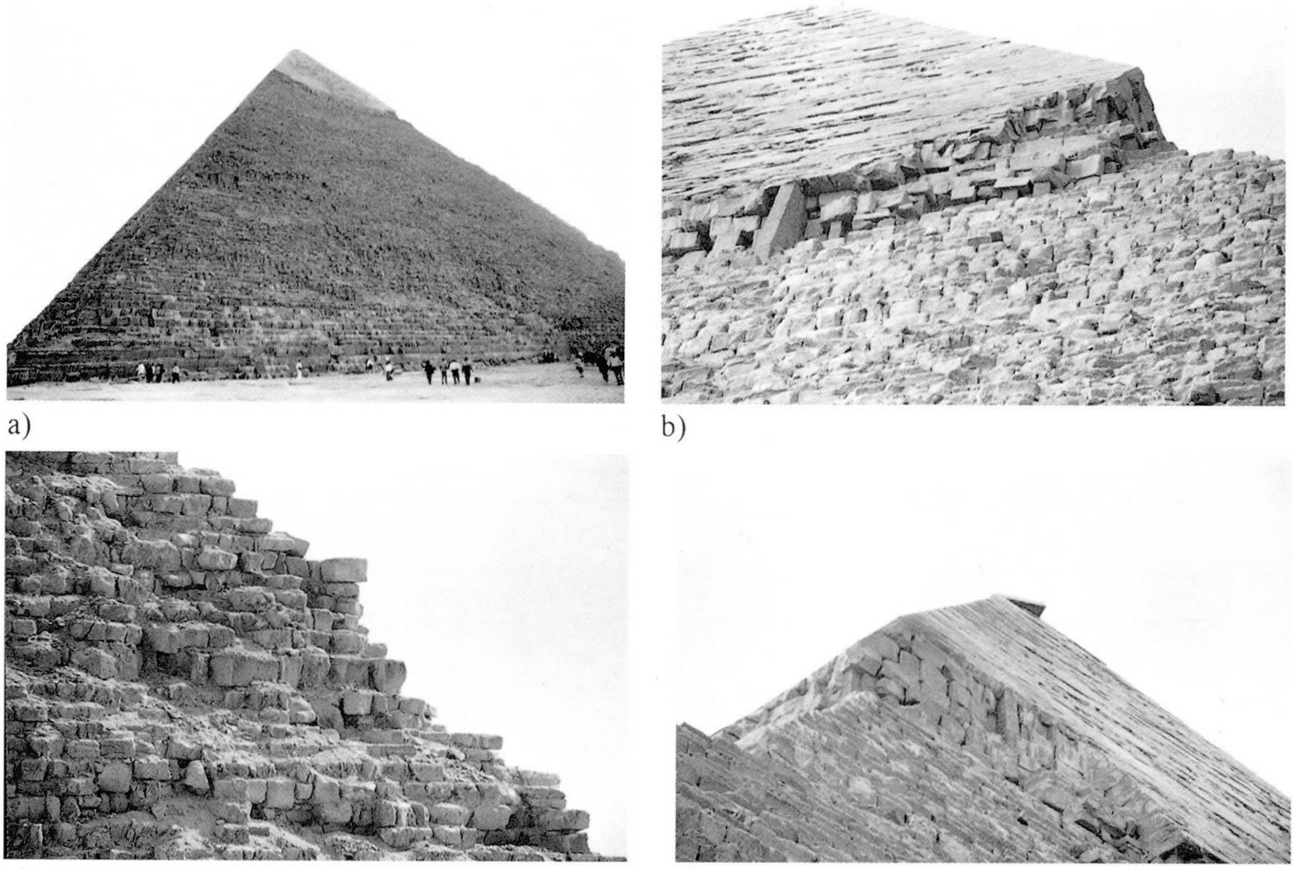
Fig 9 The Aquaduct of Segovia (a), where the perfect equilibrium of arches (b) has not been compromised by the rounding of the blocks edges by two thousand years of snow, rain and eolic action (c), but whose survival is at risk from pollution (d)

Old conceptions and old technology are not however faultless: it could be sufficient to think that the history of Architecture includes the lesser known history of damages and collapses, on the basis of which the soundest solutions have been found. Imperfect design (as in the case of the shape of the St. Ignatius dome mentioned above), lack in the continuity of the walls, especially at the corners, insufficient tensile strength of the masonry and irreversible deterioration, especially of timber elements, are just some of the problems that we heritage from the past.

In some situations, such as the Monastry of Mar Mousa in Syria (figure 11) deterioration is so high that it will be very difficult to reduce the risks to a level that a modern society requires using ancient technologies alone, especially regarding the precarious conditions of the foundations.

Therefore it must be an intelligent rather than rigid position, to evaluate in each specific case, the degree of convenience of using the original technology and old materials, also referring to the presence of new phenomena (soil settlements, earthquakes..).

d) - Modern technology. The recent and frequent use of new technology and techniques has brought about a reaction against them, that, however, as all rigid standpoints, can not always be justified. Certainly new technology should be used with a high degree of care, because its power can create irreversible damage, as can be observed in projects of the recent decades; this is made worse by the fact that much of the new technology (i.e. the insertion of steel bars in masonry, cement injections etc..) has not been throughly tested before being used in monuments and has often been applied where unnecessary without understanding the possible unfavourable side effects.



a) b)

c) d)

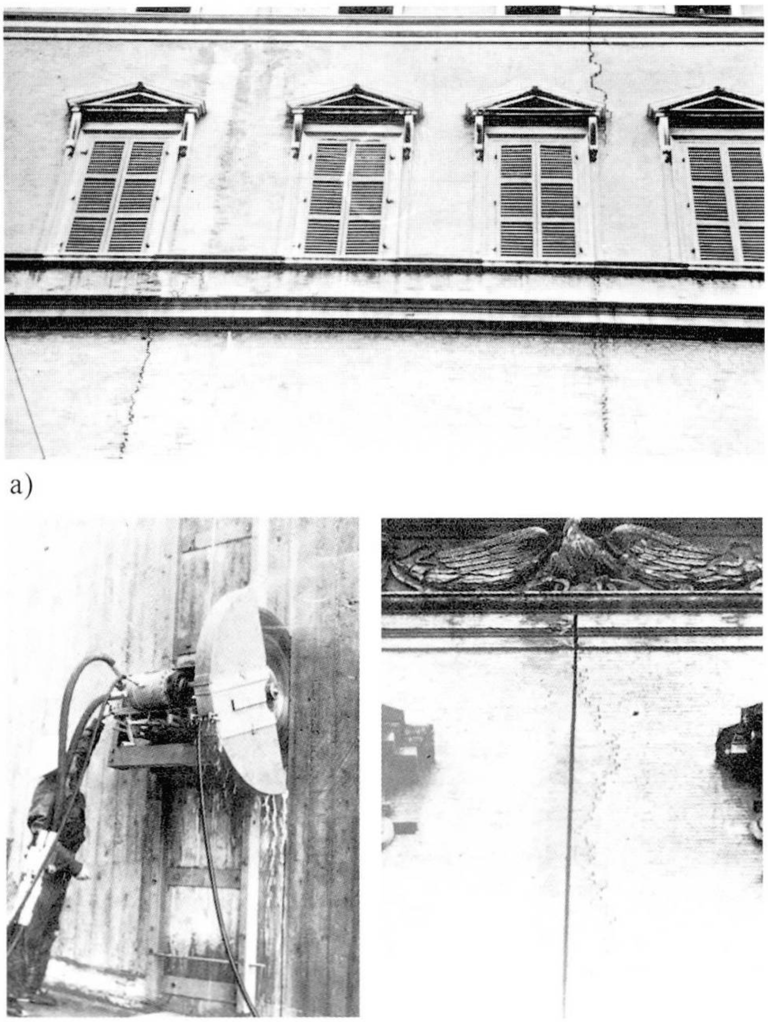
Fig. 10 The Chefren Pyramid (a) suffers from a lack of maintenance; the progressive destruction of the weak mortar and the more fragile blocks (b) has created dangerous conditions (c). The earthquakes have accentuated this situation, making some blocks fall and moving the very top (d)

Fig. 11 Monastry of Mar Mousa in Siria: deteroration of the masonry and dangerous disintegration of the stone basement

Cases of restoration works to put right what was recently restored are not unusual. The restoration branch of engineering, must make choices on the side of prudence and must be integrated by a large cultural view, where there is place for Science, History and Architecture, in order to evaluate the meaning and the consequences of any alterations to the original conception. We think anyway that, if properly used, modern technques and technology can give interesting solutions and help in the preservation architectural heritage.

The following examples highlight some significant applications.

The Ducal Palace of Modena (figure 12) was affected by significant subsidence phenomena. Fifteen years ago the problem was solved by making vertical cuts in the Palace following the main cracks in the walls, the movement joints that have been thus created allow the building to follow the soil settlements without further relevant stresses or cracking to the structure. The result has been completely satisfactory.



a) b) c)

Fig. 12 The Ducal Palace of Modena: relevant cracks in the walls due to soil settlements (a), special device for cutting walls (b) and the realization of joints (c)

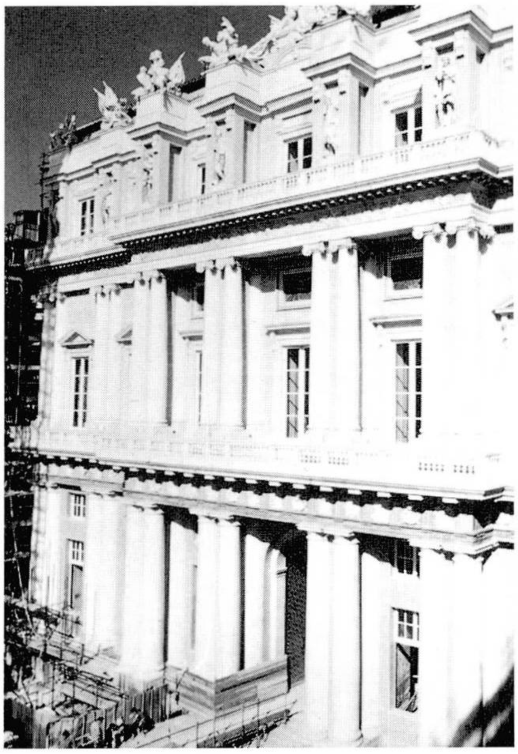
The Ducal Palace of Genoa (figure 13) suffered from foundation deformations that affected the main façade creating a loss of curvature in the main vault of the salon; the problem required the creation of an efficient connection between the opposite façades and the assurance of the stability of the vault. This was resolved by the placing of a steel arched beam, placed between the vault and the roof. This arched beam works simultaneously as a tie between the walls (for this reason an appropriate stiffness is required) and as a support for the vault by means of small connecting rods. A monitoring system, installed for a year, checked the intervention and particularly the stresses in the connecting rods; the results showed important thermal effects which lead to the replacement of the rods with springs, in order to maintain a constant supporting force. The monitoring system has been thus not only a way of control, but also a support for the final design.

One of the most important problems in restoring monuments is often the need to assure a certain level of tensile strength; modern materials can sometimes offer interesting and more efficient alternatives to the ancient iron chains, the wood ties or the weak connections realized in masonry itself.

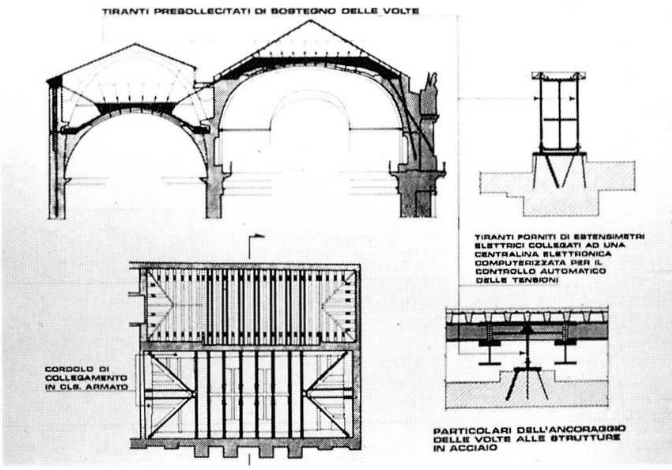
In the dome of St. Ignatius of Loyola, small prestressed stainless steel cables, normally used to sustain the masts of sailing boats, were used, having the advatages of economy and durability (figure 3); In the basilica of St. Mary of the Angels in Assisi synthetic fibre ropes of polypropilene, made by Retiflex, were used in the exterior walls (figure 14), with the double purpose of giving transversal resistance to the walls and connecting them to the façade; an appropriate pretension assured the immediate efficiency, while the very low modulus of elasticity (approx. 20,000 kg/cm2) of the same order of or less than that of the masonry, avoids zones of stress concentration and does not modify the stress distribution in the compressed zones.

Prestressed steel cables offer a wide range of applications: in Palazzo Altemps, in order to rid the main ancient saloon of subsequently constructed internal walls whilst supporting the floors that bear onto them, prestressed cables were used to reinforce the upper part of the walls that now work as beams (figure 15).

We want to mention, finally, that new technology can be very useful when the recovery of a deformation or out-of-plumb is required A system of jacks connected with a monitoring system, is currently being used while work is in progress on the foundations of the St. Michael Palace in Rome. A similar system is used to control the archeological excavation works beneath the foundations of small houses built centuries ago over the roman amphitheatre of Ancona (figure 16): a serie of provisonial steel elements created under the foundations, step by step, allow the progression of the excavation before choosing the final solution. In the Cathedral of Vitoria in Spain (figure 17)



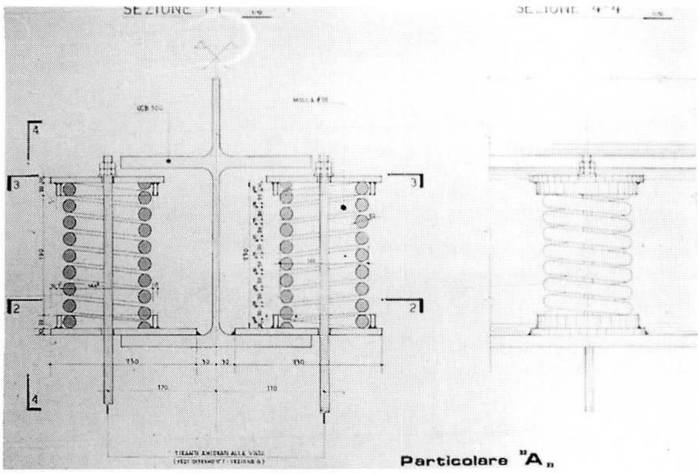
a)



c)

Fig. 13 The Ducal Palace of Genoa: the outward deformation of the façade (a) created by a loss in the curvature of the voult (b); the intervention (c) realized the connection between the opposite walls and support by means of springs (d) to the vault

b)



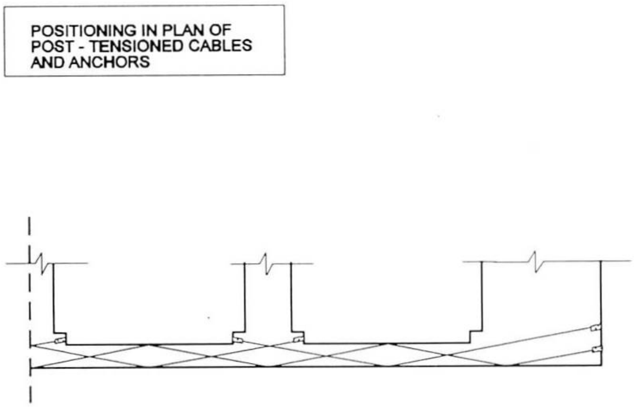
d)

provisional steel elements connected to a monitoring system are going to be used to recover the huge deformations created by ancient soil settlements.

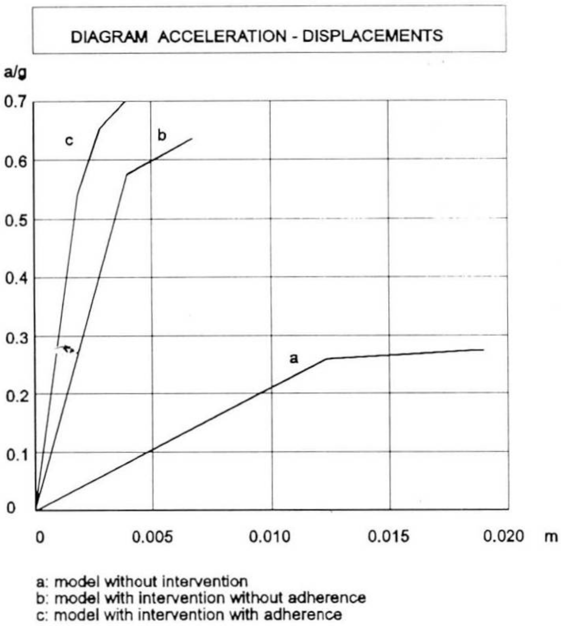
In conclusion new technology enlarges the range of choice and can offer a very useful support: it is to the culture of engineers, architects and all people involved in the preservation of Architectural Heritage to profit from this possibility in the right way.

Fig. 14 St. Mary of the Angels in Assisi was affected by seismic cracks (a) and has been reinforced with synthetic fibre (b); the diagrams show the improvement in the seismic resistance capacity calculated by non-linear analysis (c)

a)

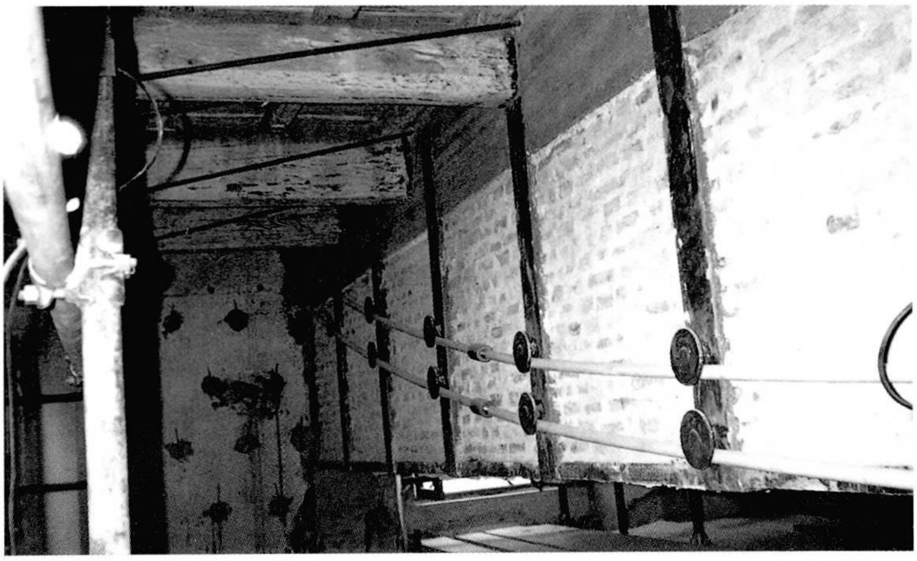


b)



c)

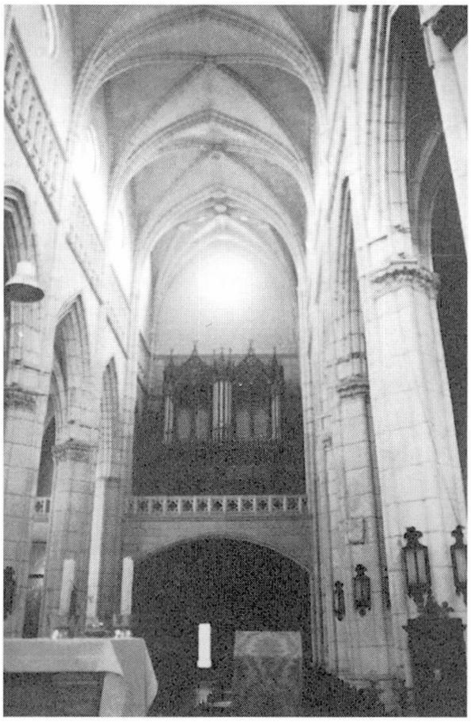
Fig. 15 Palazzo Altemps: prestressed cables to reinforce the remaining upper part of a demolished wall, working now as a "beam", to allow support for the floors above



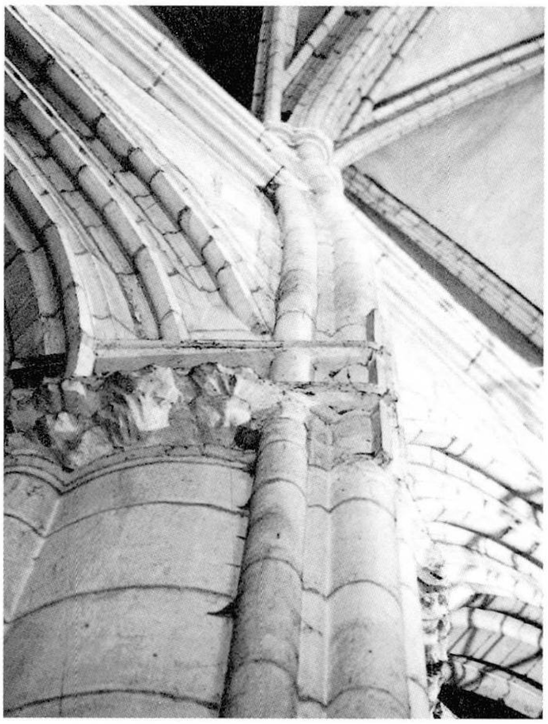
a)

b)

Fig. 16 The Amphiteatre of Ancona with houses built above (a) and excavation works under the foundations (b)



a)



b)

Fig. 17 The Cathedral of Vitoria in Spain (a) and the huge deformations of the columns (b)

4. A NEW PHILOSOPHY FOR A CODE

It is unquestionable that a code for investigations, analysis, projects, works, controls, etc.. would not just be useful but is absolutely necessary. The lack of guidance allows us to propose solutions that are often based on arbitary decisions without proof of the benefits or preliminary experimentation to discover the possible side effects. Besides which, as quality control is not always requested, there is no certitude that the expected results will be attained. The lack of a specific code is also the cause of misunderstanding and leads to the inappropriate use of other codes that are aimed for different purposes. The seismic codes created for new constructions or for the repair of seismic damages in ordinary buildings for example cannot be used, either for the characteristics of the actions (the behaviour of a monument under seismic loading is very particular) or for the techniques often proposed (extensive use of reinforced concrete,...). This problem occurred in Dubrovnik where, after the bombing of December 1991, we began to study various buildings with the view to designing restoration interventions (figure 18); as Dubrovnik is in a zone of strong seismic action, and we must follow the Croatian Seismic code, we will be obliged to introduce reinforcement heavier than that required for the repair: therefore the code risks being as damaging as the bombs, creating alterations that may compromise the historical value which has been preserved for centuries.

A similar problem is posed in the restoration of the historical walls of Urbino (figure 19), largely damaged and with a part that has recently collapsed. Calculations following the usual Code on the retaining walls show that the earth pressures are higher than the Urbino walls are capable of supporting; the designers and administrators have been left with a difficult choice, between accepting lower safety levels, thereby breaking the law or carrying out interventions that will presumably be stronger than necessary thus substantially modifying the original conception

In conclusion we can see that creating a Code expressly for the Architectural Heritage is necessary but at the same time a very complex task and thus requires a global rethinking of the overall philosophy of safety evaluation, of the reliability of the judgments and of the responsibilities involved.

a)

b)

Fig. 18 A view of Dubrovnik (a) and the damages after the bombing in December 1991 (b)

ACKNOWLEDGEMENTS

Many thanks to the engineers A.Viskovic and L.Goldfinger for their help in the preparation of this paper.

REFERENCES

1. CROCI G., La Scienza delle Costruzioni tra Teoria e Realtà: lo schema come nucleo della conoscenza scientifica. L'Industria delle Costruzioni, July 1979.

2. CROCI G., Interventi nel Palazzo Ducale di Modena interessato da fenomeni di subsidenza. Convegno Nazionale di Geotecnica, Firenze, 1980.

3. CROCI G., Safety of the "Tabularium and Palazzo Senatorio" Monuments. IABSE Symposium, Venezia, 1983.

4. CROCI G., The Role of Monitoring for the Knowledge of the Behaviour of Structures. IABSE Colloquium, Bergamo, 1987.

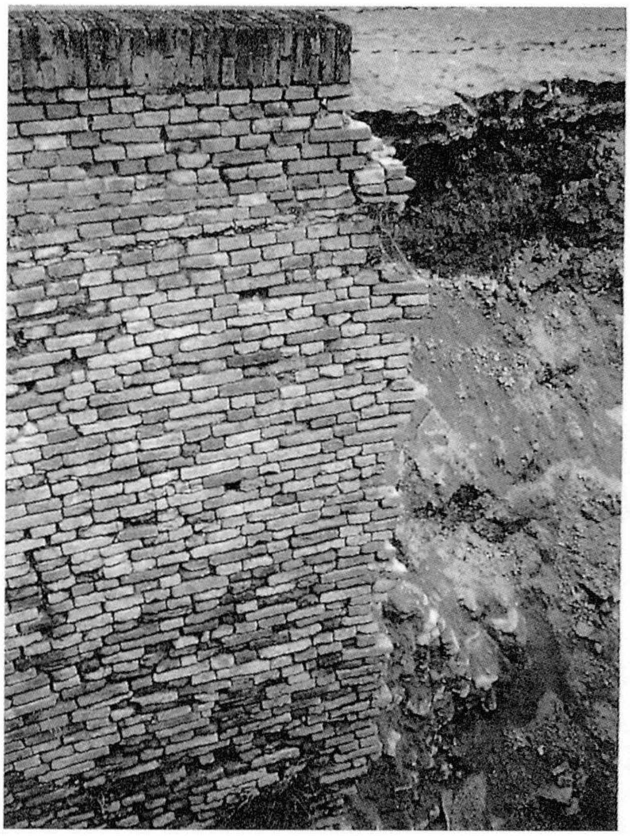
5. CROCI G., CARLUCCIO G., ASTRAIN CALVO L., AMMAN E., Diagnostic, Monitoring and Reinforcement of the Dome of the Cathedral of Saint Ignatio de Loyola in Azpeitia. STREMA, Siviglia, 1991.

6. CROCI G., D'AYALA D., CONFORTO M.L., The origin of the cracks and failures in the history of Colosseum in Rome. International Congress on Restoration of Architectural Heritage and Buildings, Canarias, 1992.

7. CROCI G., CARLUCCIO G., VISKOVIC A., The structural analyses and restoration projects for the St. Francis, St. Claire and St. Mary of the Angels Basilicas in Assisi. STREMA, Bath, June 199

Fig. 19 A view of the Urbino walls (a), a collapsed zone where it is possible to see the poor condition of the masonry (b, c)

a)



b)

c)

Social and Economic Aspects of Monument Preservation

Aspects sociaux et économiques de la conservation des monuments

Soziale und wirtschaftliche Aspekte der Denkmalpflege

Nathaniel LICHFIELD
Professor Emeritus, Partner
Lichfield Assoc.
London, England

N. Lichfield, Professor Emeritus of the Economics of Environmental Planning in the Univ. of London and past President of the Royal Town Planning Institute, has an international reputation as a planning economist, particularly in development economics, project evaluation, financial, social cost-benefit analysis and community impact analysis. He has directed studies for and advised government, public offices, landowners and commercial developers in the UK and around the world.

SUMMARY

The architectural heritage is part only of the general heritage of mankind. Various types of preservation works are presented under the title 'conservation'. A special case of urban renewal illustrates the economic decisions that need to be taken as a preliminary to the conservation. In these decisions, the cost side is familiar to engineers but the value side is not, so that some indication is given of measuring value in practice. A distinction is drawn between an analysis of costs and benefits in financial and economic terms. In order to reach a decision in the public interest, a method of comparison termed community impact evaluation is offered.

RÉSUMÉ

Le patrimoine architectural n'est qu'une partie de l'héritage laissé à l'humanité. Différents travaux de conservation sont présentés. Un cas particulier de rénovation urbaine illustre les décisions économiques qui doivent être prises avant les travaux. Dans de telles décisions, l'ingénieur est familier avec l'aspect 'coût' mais pas avec l'aspect 'valeur', de sorte qu'il doit être conseillé dans la pratique. Une distinction est faite dans l'analyse des coûts et des bénéfices, en termes financiers et économiques. Afin d'effectuer un choix dans l'intérêt général, une méthode de comparaison appelée "évaluation de l'impact sur la collectivité" est proposée.

ZUSAMMENFASSUNG

Denkmalpflege ist Teil des gesamten Erbes der Menschheit. Verschiedenartige Unterhaltsarbeiten werden unter dem Begriff "Erhaltung" angeboten. An einem städtebaulichen Renovationsbeispiel wird gezeigt, welche wirtschaftlichen Entscheide vor der Arbeitsaufnahme notwendig sind. Bei diesen Entscheiden ist der Ingenieur zwar mit dem Faktor Kosten, jedoch nicht mit dem des Wertes vertraut. Dafür braucht es Erfahrung. Es wird zwischen einer Kosten- und Nutzenanalyse in finanzieller und wirtschaftlicher Hinsicht unterschieden. Um eine allgemeingültige Wahl zu ermöglichen, wird ein geignetes Verfahren vorgeschlagen: "Auswirkungen auf das Gemeinwohl" .

1. Focus of Paper

As the title of this symposium conveys, the engineer's concern with the architectural heritage relates primarily to structural preservation. In this he will at least intuitively have regard to the economic aspects to be borne in mind in the structural design, in terms of what is generally termed "engineering economics". But in this he will look to the contribution of economics from specialist members of the team involved in the project. Their possible contribution is wide and there is room here to introduce only a limited number of considerations.[1]

I start by showing that the architectural heritage is part only of the general heritage of mankind (2) and the special characteristics of the architectural heritage (3). Then comes an enumeration of the various types of preservation works that can be carried out, with the suggestion that they all can be subsumed under the title "conservation" (4). Such conservation is best seen as a special case of urban renewal (5) which leads on to the economic decisions that need to be taken as a preliminary to the conservation (6). In these decisions, the cost side is familiar to engineers but the value side is not, so that some indication is given of measuring value in practice (7). A distinction is then drawn between an analysis of costs and benefits in financial and economic terms (8). This leads to a display of the wide array of gainers and losers in conservation, bringing with it a need to weigh them up to reach a decision in the public interest, by a method of comparison termed community impact evaluation (9). There are various methods of evaluation, so that particular decision takers would need to choose that which serves their interests, or else reach false conclusions. The paper ends with a typology of various decision takers/makers that could be involved in conservation, with an indication of the costs and benefits they would consider and therefore of the method of evaluation that they would choose (10).

2. The Architectural Heritage is Part of the General Heritage

The term <u>heritage</u> denotes all that which is <u>inherited</u> by any generation from previous generations. Such heritage can be very diverse, as the following typology will show: [2]

Physical Stock

(a) natural resources: land, with its minerals, agriculture and timber products, animal and bird life; the water, with its fish and plant life; the environment in sun, air, rain, climate;

(b) man-made: works and buildings which are attached to the land (immobile);

(c) man-made: works which are not attached to walls and building (mobile).

Activities

(a) consumption: quantity and kind of goods and services available to people for their standard and quality of life;

(b) production: way in which society has learned to provide the goods and services for consumption;

(c) religion: relation with the God(s) of the country and the institutions which service that relation;

(d) arts: graphic, music, dance, literature, film, plays;

(e) knowledge: accumulated and transmissible through education and training of all kinds;

(f) Folklore: collective memory of past generations, absorbed through the family, teachers, etc.;

(g) Tradition: carrying out activities in a manner reminiscent of previous generations.

3. The Special Characteristics of the Architectural Heritage

From this it is seen that the architectural heritage is one element of the physical stock which is inherited, namely the man-made works and buildings which are attached to the land, and thereby immobile.

However, not all this general architectural heritage can be said to be cultural. This term relates to a minor part of the man-made general heritage in works and buildings which expresses some indefinable but recognisable element which current society values especially, and which it wishes to make special efforts to pass on to posterity. The division between what is to be passed on or not is obvious in certain instances (for example traditional cooking versus harmful drugs) but not in others (for example classical versus jazz music). This distinction is not hard and fast over time but is made by successive generations in some kind of consensus of elite choice, as for example the paintings and objects which find their way to private or public museums. Such choice is reviewed by successive generations. In this it follows that any efforts of preservation by a particular generation may be either welcomed or rejected by succeeding generations. Thus even if the well known conservation ethic persists, that our cultural heritage belongs not to us but to our children for whom we are trustees, it could well be that the children may not appreciate or cherish the bequest that they have had. Such, after all, is the privilege of all children.

The "architectural heritage" with which our symposium is concerned clearly relates to buildings which have architectural merit. But this is part only of what is more generally termed the <u>cultural built heritage.</u> In this can be found a wide array of isolated objects such as archaeological sites; ancient monuments (buildings which remain in whole or ruins which are typically not occupied nor capable of occupation); individual buildings or groups; streets and ways connecting the groups; objects such as single standing columns or statues; or whole areas, be they ones which in themselves have a heritage value or, having no such value, are nonetheless of importance because they are surrounding or nearby part of the cultural built heritage itself. Within this, it will be seen, or can be found, buildings or groups of buildings which are occupied for contemporary uses; or archaeological sites, ruined churches or statues which are not.

This array of examples brings out one unique feature of the cultural built heritage. The cultural aspects, be it derived from architecture, history, association with important events etc. is an integral part of the buildings and structures in which it is found. From this four facts flow. First, in order to protect and preserve the heritage it is necessary to protect and preserve the man-made works themselves. Second, the carrying out of protection and preservation of the structure itself could result in either a diminution or enhancement of the cultural element. Third, the man-made works, be they in private or public ownership, are typically the property of some legal entity thus, fourth, the works of preservation must be carried out in accordance with the law relating to real property (i.e. of land and buildings).

All these characteristics make for special problems in the preservation and conservation of the cultural built heritage.

4. Preservation is Part of Conservation

Preservation of the cultural built heritage can take many forms, as the following typology shows: [3]

(1) prevention of deterioration (indirect conservation); by for example a sound maintenance programme and controlling environmental pollution;

(2) preservation: keeping the object in its existing state of repair to prevent further decay;

(3) consolidation: adding or applying supportive materials into the actual fabric in order to ensure its continued durability and structural integrity;

(4) restoration: reviving the original concept, either or both in relation to the fabric or use (also called restitution);

(5) rehabilitation: adapting the building to a contemporary use which will be capable of sustaining it (also called reconditioning, renovation, remodelling, adaptive use);

(6) reproduction: copying and existing artefact in order to replace some missing or decaying parts; or in extreme circumstances moving the object to a more suitable environment;

(7) reconstruction: rebuilding anew in imitation of the old, as necessitated by disasters such as fire, earthquake or war. The reconstruction could take place on the same site or in extreme cases, another.

From the list it is seen that the "preservation" of the cultural built heritage can take many forms, each attracting its own terminology. While the differences are important in practice, for our purposes they can all come under the umbrella of 'conservation', a term we now adopt.

5. Conservation as a Special Case of Urban Renewal

One generalisation can be made about all elements of the cultural built heritage. By definition, they tend to be fairly aged, having been constructed in the past, and thereby subject to the fate of all man-made structures, namely obsolescence. This characteristic is not only the familiar one of physical decay of any structure exposed to the elements, but also from other causes. It may relate to function, as where the initial design is no longer suited to contemporary usage. It may be locational, as where contemporary social and economic activities have outmoded the original site, as could happen in a cattle market. And finally there is the environmental obsolescence, as where the twentieth century increase in motor traffic has made a building unusable for an office or school.

Faced with such obsolescence, the owners and occupiers would inevitably consider taking remedial action, by modernising, remodelling, refurbishment or perhaps demolition for a new structure. In this they will primarily follow their economic interests. But when the conservation/preservation restriction is applied their freedom to do so is undermined. They must follow the rules prescribed by the conservation authority. Should they wish to renew they must do so with conservation/preservation as a constraint.

6. The Economic Decision

All these remedial actions are open to the owner occupier in making decisions to carry out renewal against obsolescence. Their decisions lie inherently in economics. This means that in any of these actions they will consider the relationship of the input of resources (costs) and output of values (benefits), by means of cost benefit analysis. Of particular relevance here on the output side is the alteration (diminution or enhancement) in the quality of the cultural built heritage.

Controversy arises in conservation, on the relationship of these costs and benefits. Should conservation be based on the axiom that since it has aimed at a cultural not commercial value it is to be carried out regardless of cost? Or is conservation, like all other things in life, subject to the necessity, on the following propositions, of achieving "value for money". If costs are ignored, and the decision based simply on the cultural values, it could follow that a significant share of total available resources would be needed for a comparatively insignificant enhancement in total cultural value. If on the other hand only minimal costs are employed it could be that there would be unacceptable erosion of cultural quality. Since the resources available for conservation are invariably limited (in the sense that they cannot match up to all the requirements) we need to be sure that they are used with discrimination for the conservation objectives. Any fixed budget should be spent to achieve the maximum possible value in heritage quality; it should be made most effective in achieving heritage quality.

We thus need to explore the conventional economics relationship between cost and value (benefit). This relationship is tested by three classical questions, which are also familiar in engineering:

(a) Should the project be carried out at all? Generally speaking it should not, unless the value of the output exceeds the cost of the input.

(b) Should the project be carried out in the way proposed? Generally this can be answered only as a result of applying the first question to a series of options, which would bring out that in which the excess of value over costs is the greatest.

(c) Should the project be carried out now? Or would conditions sometime in the future provide a more favourable answer to the preceding 2 questions?

The tests can be applied to the cultural heritage in two senses:

(a) To the property in question, including the heritage element, as in conventional real estate valuation [4]. In essence, what is the property worth in the market in its current condition? And would the costs of the proposed works exceed or not by sufficient margin the added value which results to justify the work and risk of the investment? If not, the project should not be carried out, unless someone (e.g. Government by grant) is willing to meet the shortfall in order to conserve the heritage quality.

(b) Since the purpose of the project is preservation/conservation of the heritage, the same approach is applied simply to the cultural element of the property above and not the property itself. For this purpose it is necessary to establish the level of cultural value in the property as it stands, and then to consider whether the difference in cultural value as a result of the works would be negative or positive, and by how much. If negative, then from the cultural viewpoint the project should not be pursued. If positive, is the amount of added cultural value justified in relation to the cost incurred.

To pursue the latter question, it is necessary to be able to assess the level of quality in the heritage, before and after. More strictly the contrast should be "without" and "with", where the former answers the question: what would happen to the cultural quality in the future under the conditions where no expenditure, or only minimum expenditure, were carried out.

Difficulties arise however in assessing the value of the cultural element, simply because in itself it is not bought or sold in the market, and therefore has no identifiable market price to indicate the value. For example, a listed building in everyday use as an office could have considerable market value related to that use, which only reflects in part the cultural value. Conversely, a former cotton mill could have significant cultural value as industrial archaeology but may have negative market value as property, since it is functionally obsolete and not functionally suitable for new uses. A more extreme example is the ruined castle or monument, which must be kept that way because of its considerable heritage but has no use value and thereby no market value.

7. Valuing the Heritage Quality

We now proceed to consider how the cultural valuation can be estimated.
The logic behind the method can be grasped by considering the everyday valuation of a house or flat for purchase for say $250,000. In offering or paying this price the purchaser in a sense is accepting that the attributes of the dwelling (number of room, adequacy of bathrooms and kitchen, size of private garden or terrace, aspect of the house, freedom from traffic noise etc.) can be expressed by the index of market price, with differences in price reflecting differences in quality of attributes. But where there is no price, the implicit reasoning can be applied: what are the comparative attributes of the cultural quality in question compared with others?

In illustration is presented one such method which has been well articulated in Canada for in grading the quality of the cultural built heritage when making decisions as to whether or not include the property on the list for protection [5]. Diagram 1 illustrates. On the left are shown five basic criteria (A-E), each with sub-criteria (totalling 20), which have four sub-divisions. Each attracts its own score in points, allocated within a predetermined maximum, as follows: The five basic criteria are allocated a maximum of 100, which are respectively weighted 35, 25, 10 and 15. Each of the sub-criteria is then graded by points which are allocated to the following verbal description, the points distribution reflecting a geometric rather than arithmetic progression in order to distinguish more sharply between the different qualities:

E	Excellent
VG	Very Good
G	Good
F/P	Fair or Poor

8. Financial and Economic Costs and Benefits [6]

In considering the economic decision on 6 above we have taken account of the costs and benefits which would fall on the agency concerned with carrying out the conservation project. However, when the costs and benefits are considered from the viewpoint of the community the estimating basis is different. The costs are not considered as those financial costs falling upon the promoting agency but as economic costs falling on the community as a whole. In essence, the estimates are made in terms of shadow prices, which reflect the social value of the costs incurred and we now pursue the distinction for costs and their benefits.

Costs

a) Direct:

- Interest on money invested is ignored, since this is simply the cost which is transferred between the borrower and lender, so that the economy as a whole is no worse off as a result.
- Whereas to the financial investor it is important to accumulate the financial resources needed to replace the asset when it is scrapped, to the economy as a whole what matters is the use of resources when replacing the assets. Thus investment to accumulate financial funds to command those resources at the appropriate time are not relevant.
- Import or export duties imposed by government on materials used for the preservation/conservation do not relate to the real inherent cost and are thereby ignored.
- Should unemployed labour be utilised on the project, the cost is ignored because no extra call on economic resources is made for that purpose.

b) Indirect:

The promoting agency will of necessity ignore the costs which it has to incur and benefits for which it cannot charge. These are nonetheless of concern to the community as a whole, since by definition they must be borne by others. Some examples are:

- Noise and disruption on amenity of the site itself, caused by its use for the construction and by visiting lorries for discharge of materials.

- Should the lorry traffic to the site be so considerable as to disrupt traffic, and possibly cause accidents, then costs would fall on the community in terms of additional traffic control, hospitalisation etc.

Benefits

In parallel there would be a difference on the benefits side. Some examples are:

a) Direct

- Where the heritage in question is visited by tourists, tourist income would be generated such as admission prices, expenditure on memento's, books etc.

- Even if the cost of unemployed labour were ignored, there would be psychic benefits from employment to the persons involved and saving to government in welfare payments.

b) Indirect

- The conservation could, by introducing stability into an area whose future was in doubt, also increase the values of surrounding properties and of surrounding land for new development.

- The employment of skilled craftsmen on the preservation/conservation could add to the supply of such workforce which would be available for other projects.

From this comparison it is seen that the conclusions on the conservation project could produce different numerical answers when seen from the viewpoint of the promoting agency or the community as a whole. Thus while the two approaches to the investment decision are similar in intent they are distinguished in practice in the methodology they use, namely financial or investment appraisal on the one hand and cost benefit analysis on the other.

9. Gainers and Losers in Conservation

From the preceding it is seen that the costs and benefits of preservation/conservation can be wide-spread, and have different impacts for different groups in the community. In essence there will be both gainers and losers. This incidence can be seen from Diagram 2 which follows, taken from a case study which compared by community impact evaluation the options for conservation (A) or redevelopment (B) of a site in Jerusalem [7].

For ease of comprehension, the sectors who are impacted are divided between those who can be seen to be contributing towards the production and operation of the conservation project, and those who would be consuming directly or indirectly the consequential outputs. Against each of the 16 sectors are indicated the type of impact, namely Direct (b) and indirect (AF for associated financial and AR for associated real).

From this it follows that when a community needs to decide on a particular conservation project it needs to weigh up and balance the differential spread of impact in order to reach a view as to what is in the community interest; and by the same attempt it can trace through the non-cultural advantages and disadvantages of the investment made in the cultural project. Diagram 2 introduces the form in which this can be done. In column 6 is posed the sectoral objectives of each of the community sectors and in column 8 the differences to those sectors when conservation (option A) is compared with redevelopment (option B). This leads to the preference being shown in columns 9 and 10, as a basis for the judgement on net benefit to the community.

10. The Choice of Evaluation Method

From the preceding it is apparent that different methods of evaluation of preservation/conservation are available, according to the viewpoint of those raising the question. Each is interested in a particular array of costs and benefits, and each would wish to form a conclusion based upon that selection. It is these requirements which dictate the method. Put another way, any particular method of evaluation which is adopted, with its implied selection of costs and benefits, would decide the answer.

This is illustrated in Diagram 3 which shows on the left-side are the array of costs and benefits/disbenefits which potentially could arise in any conservation project. In the columns are shown eight different possible decision takers who could be concerned. each would select from the possible costs and benefits/disbenefits to suit their own interests. For example:

Column 1-2: the owner and developer/entrepreneur is primarily interested in the financial analysis of costs and benefits.

Column 3: the occupier might be also interested in the cultural benefits.

Column 4: the municipality would be interested in financial costs but on the benefit side would be concerned with the fiscal impact and the cultural impact, their analytic tool being cost revenue analysis.

Column 5-6: the conservation society which is a pressure group for the cultural qualities would be concerned primarily with that. This would interest also the conservation authority who would also be concerned with the financial cost to them. Their tools would be cost effectiveness or cost benefit analysis.

Column 7: the planning authority, needing to make its decision in the public interest, would be concerned with all possible costs and benefits, using for the purpose community impact analysis.

Column 8: the government would also have a wide interest, but would be more restricted. It would be concerned with financial and economic costs and benefits/disbenefits, together with cost revenue analysis.

The choice of a particular method by any decision taker/maker clearly shows that how different parties will reach different conclusions on the decisions of any particular project.

References

(1) For a wider statement see LICHFIELD, NATHANIEL Economics in Urban Conservation (Cambridge: Cambridge University) (1988).

(2) LICHFIELD (1988) chapter 4.1

(3) FEILDEN, BERNARD M Conservation of Historic Building (London: Butterworths Press) (1982).

(4) For example, BARLOW, CLIVE (ed) Valuation and Investment Appraisal (London: The Estates Gazette)

(5) KALMAN, HAROLD The Evaluation of Historic Buildings (Ottawa: Ministry of the Environment). Reproduced by Lichfield (1988) chapter 10 (1980).

(6) SUGDEN, ROBERT AND WILLIAMS, ALAN The Principles of Practicable Cost Benefit Analysis (Oxford: Oxford University Press) (1978).

(7) LICHFIELD Chapter 15 and Part IV (1988).

DIAGRAM 1
EVALUATION OF CULTURAL QUALITY IN BUILDINGS BY POINTS SCORING

A	Building Evaluation Sheet with numerical scores				
	Name				
	Location				
	Reference Number				
B	Architecture	(Maximum 35)			
	1. Style	20	10	5	0
	2. Construction	15	8	4	0
	3. Age	10	5	2	0
	4. Architect	8	4	2	0
	5. Design	8	4	2	0
	6. Interior	4	2	1	0
C	History	(Maximum 25)			
	7. Person	25	10	5	0
	8. Event	25	10	5	0
	9. Context	20	10	5	0
D	Environment	(Maximum 10)			
	10. Continuity	10	5	2	0
	11. Setting	5	2	1	0
	12. Landmark	10	5	2	0
E	Usability	(Maximum 15)			
	13. Compatibility	8	4	2	0
	14. Adaptability	8	4	2	0
	15. Public	8	4	2	0
	16. Services	8	4	2	0
	17. Cost	8	4	2	0
F	Integrity	(Maximum 15)			
	18. Site	5	3	1	0
	19. Alterations	5	3	2	0
	20. Condition	5	3	2	0
	Total Score	A	B	C	D

DIAGRAM 2

Table 15.9 *Evaluation of options (on completion)*

No.	Community sector Description	No.	Project variables	Impact type	Sectoral objective	Units	B–A	Preference for Sub-sector	Preference for Sector
1	2	3	4	5	6	7	8	9	10
	PRODUCERS/OPERATORS								
1	Current landowner of site		1, 2, 3	D	Increase land value (net of betterment tax)	£	–	A	A
3	Developer/financier		3	D	Increase development profits	£	+	B	B
5	Municipality on site								
	(1) Roads/utilities		1	D	More municipal services		0	=	
	(2) NHM		2	D, AF	–do–		–	A	
	(3) Grove		2	D	–do–		–	A	
	(4) Open space		2	D	–do–		+	B	
	(5) New flats		3	AF	More Betterment Tax	£	+	A	A
					Preference for Sector 5				A
7	Government on site								
	National heritage		2	D	Conserve heritage		–	A	A
9	Municipality off site		1	AR	Reduce traffic congestion		0	=	=
11	Other landowners:								
	(1) adjoining		3	AR	Increase land value	£	0	=	
	(2) elsewhere		3	AF	Increase land value	£	–	A	
					Preference for Sector 9				
13	Jerusalem economy								
	(1) Employers/firms		2, 3	AR	More business		–	A	
	(2) Urban services		1	AR	More accessibility		0	=	
			2	AR	More business		–	A	
			3	AR	More business		+	B	
					Preference for Sector 15				N/C
13	Government budget		3	AF	Greater financial contribution to Sha'arey Tsedek Hospital from landowner	£	–	A	A
	CONSUMERS								
2	Current occupiers of site		1, 2, 3	D	Minimise disturbance		0	=	=

4	**Residents in flats**	3	F	Secure flats in good location		+	B	B
6	**Users of site**							
	(1) traffic on site	1	D	Minimise traffic nuisance		0	=	
	(2) visitors to NHM	2	AR	Enjoy NHM		–	A	
	(3) visitors to grove	2	D	Enjoy grove		–	A	
	(4) visitors to open space	3	D	Enjoy new open space		+	B	
	(5) passers by	3	F	Enjoy new view over town		+	B	
				Preference for Sector 6				A
8	Tourists and visitors	2	AR	Enjoy the cultural built heritage		0	A	A
10	Traffic							
	(1) to site		AR	Reduce congestion		0	=	
	(2) general		AR	Increase accessibility		0	=	
				Preference for Sector 10				=
12	Other occupiers:							
	(1) adjoining	2, 3	AR	Increase occupation value		0	=	
	(2) elsewhere	2,3	AF	Maintain occupation value		–	A	
				Preference for Sector 12				A
14	Jerusalem economy							
	(1) workforce	1, 2, 3	AR	Greater number of jobs		?	N/C	
	(2) nearby residents – air/visual	2, 3	F	Greater environmental attraction		–	A	
	(3) downtown users	2, 3	AR	Greater interest		–	A	
	(4) users of urban services	2, 3	AR	Greater accessibility		+	B	
				Preference for Sector 14				N/C
16	**Taxpayers**	2,3	Af		£	–	A	A

Notes: Col. 7 : the gap shows measurement other than in £
8 : +, B is better than A
–, B is worse than A
0, B equals A
9 : ?, non-certain
9 & 10 : A & B are equal
N/C, preference not certain

DIAGRAM 3
SCHEMA FOR COSTS AND BENEFITS/DISBENEFITS
CONSIDERED BY DIFFERENT MAKERS AND TAKERS OF DECISION ON A PROJECT

	DECISION MAKER/TAKER							
Kinds of Costs and Benefits/Disbenefits	Owner	Developer/ Entrepreneur	Occupier	Municipality	Conservation Society	Conservation Authority	Planning Authority	Government
	1	2	3	4	5	6	7	8
COSTS/RESOURCES								
Financial	x	x	x	x		x	x	x
Economic							x	x
BENEFITS/DISBENEFITS								
Financial	x	x	x				x	x
Fiscal				x			x	x
Economic							x	x
Social							x	
Health							x	
Cultural			x	x	x	x	x	x
Environmental							x	
Traffic							x	
Possible Analytic Tool	FA	FA SFA	FA	CRA	CE	CBA	CIA	SFA SCBA CRA

New Parameters for the Preservation Movement

Situations nouvelles dans la conservation du patrimoine architectural

Neue Verhaltensmuster bei der Denkmalpflege

James Marston FITCH
Dir., Hist. Preservation
Beyer Blinder Belle, Archit.
New York, NY, USA

J. M. Fitch, with a DHL degree of the Columbia Univ. and a DArts degree of the Kansas State Univ., studied architecture at Alabama and Tulane Universities. He is founder and director emeritus of the graduate program in historic preservation at Columbia Univ.

SUMMARY

The preservation of the architectural heritage involves different bodies according to the country: voluntary organizations in USA, governmental agencies in Europe and elsewhere. Both approaches have advantages and shortcomings. The author reviews the evolutionary processes of the preservation movement in the USA and illustrates it with four case studies in New York.

RÉSUMÉ

La conservation du patrimoine architectural est réglée de façon différente selon les pays; aux États-Unis ce sont plutôt des associations de bénévoles alors qu'en Europe et ailleurs, ce sont des organismes gouvernementaux. Les deux pratiques ont leurs avantages et leurs inconvénients. L'auteur passe en revue le développement des mouvements pour la conservation du patrimoine architectural et présente quatre études de cas à New York.

Zusammenfassung

Die Denkmalpflege wird je nach Land durch unterschiedliche Körperschaften wahrgenommen; in den Vereinigten Staaten sind es eher Wohlfahrtsorganisationen, in Europa und anderen Regionen gibt es dafür staatliche Institutionen. Beide Vorgehensweisen haben ihre Vorzüge und Nachteile. Der Autor schildert die Entwicklungsgeschichte der amerikanischen Denkmalschutzorganisationen und stellt die praktischen Auswirkungen anhand von vier Fallstudien in New York dar.

New Parameters for the Preservation Movement

The American preservation movement has always been fundamentally populist and decentralized, dominated by voluntary organizations of lay persons (preponderantly women) and lacking legislative support and governmental financing. On the other hand, preservation in Europe and elsewhere, has always been institutionalized, with centralized governmental agencies supported by strong legislation and funding like the French *Service des Monuments Historiques* and the Italian *Soperintendenza dei Monumenti*. There are advantages and shortcomings in both approaches; but one advantage unique to the American system has been that it has generated an authentic mass movement which is becoming increasingly decisive in the battle to save the environment, man-made and God-made alike.

Though it had been consistently ignored by the architectural profession until the post-World War II years, the American preservation movement had been steadily growing since Ann Pamela Cunningham had formed the Mount Vernon Ladies Association in 1859 to save and restore George Washington's homeplace. In fact, the history of the movement can be summarized in three of its most prestigious restorations -- Mount Vernon (begun 1865); Williamsburg (envisioned in 1926); and Independence Hall (begun 1966). Not only do they represent three key sites in American history -- "the homeplace of the father of our country"; the site of Patrick Henry's famous cry, "Give me liberty or give me death!"; and the room in which the Declaration of Independence proclaimed to the world, "We hold these rights to be inalienable -- life, liberty and the pursuit of happiness." They also represent quite well three stages in the philosophical and technical development of the field itself.

The American preservation movement has always been propelled into action to save what it could of the built world which was threatened, especially after the Civil War, by the rise of industrialism and the spread of urbanism. The Mount Vernon Ladies Association was to become the prototype of such citizens' organizations, which today number thousands. Initially, the movement was strongest along the East Coast and centered in those cities where the largest proportion of eighteenth and nineteenth century buildings survived -- Boston, New York, Philadelphia, Washington, Charleston, Savannah and New Orleans. And it was in these areas that the first regional preservation organizations were established: The American Scenic and Historic Preservation Society (1901); The Association for the Preservation of Virginia Antiquities (spring of 1888); The Society for the Preservation of New England Antiquities (1910); the Society for the Protection of Long Island Antiquities. The National Trust for Historic Preservation was founded by an act of Congress in 1949.

The years before World War II saw the final flowering of historical eclecticism in architecture and, simultaneously, the emergence of historic preservation. The two movements were parallel and esthetically related; but they were actually motivated by two quite different attitudes towards the architectural past. The one represented the architectural profession's reliance upon the routine use of historic styles in the day-to-day design of new buildings. The other represented the antiquarian's ambition to save actual old buildings for their artistic and/or historic merit. Although the end products of these two movements might often appear superficially similar, they were basically as different as originals and facsimiles always are. Thus eclectic architects were

Williamsburg, Virginia. Restoration begun circa 1935. Shown here, Duke of Glouster Street in circa 1925.

Williamsburg, Virginia. Restoration begun circa 1935. Shown here, Duke of Glouster Street in circa 1960.

producing such projects as the brand new "Colonial" campus for Duke University at Raleigh, North Carolina or Addison Mizner's "Spanish Colonial" villas and town center at Palm Beach, Florida; while simultaneously the preservationists were setting about the preservation of hundreds of authentically old buildings and old towns like Williamsburg and passing revolutionary new legislation to preserve the historic cores of Charleston and the old Franco-Spanish Vieux Carre of New Orleans.

Although there had been decades of essentially amateur preservation projects around the country, Williamsburg was our first fully professional one in which architects, landscape architects, archaeologists and historians had collaborated on a programmatic basis. Developments in the subsequent sixty years have been immense -- in both conceptual and quantitative terms -- so immense, in fact, as to make Williamsburg itself seem amateur and to suggest that the term historic preservation itself is no longer adequate to describe the field today. I, myself, have been forced to coin a modifying clause: curatorial management of the built world.* Nothing less seems adequate to describe our broadened understanding of the tasks which confront us.

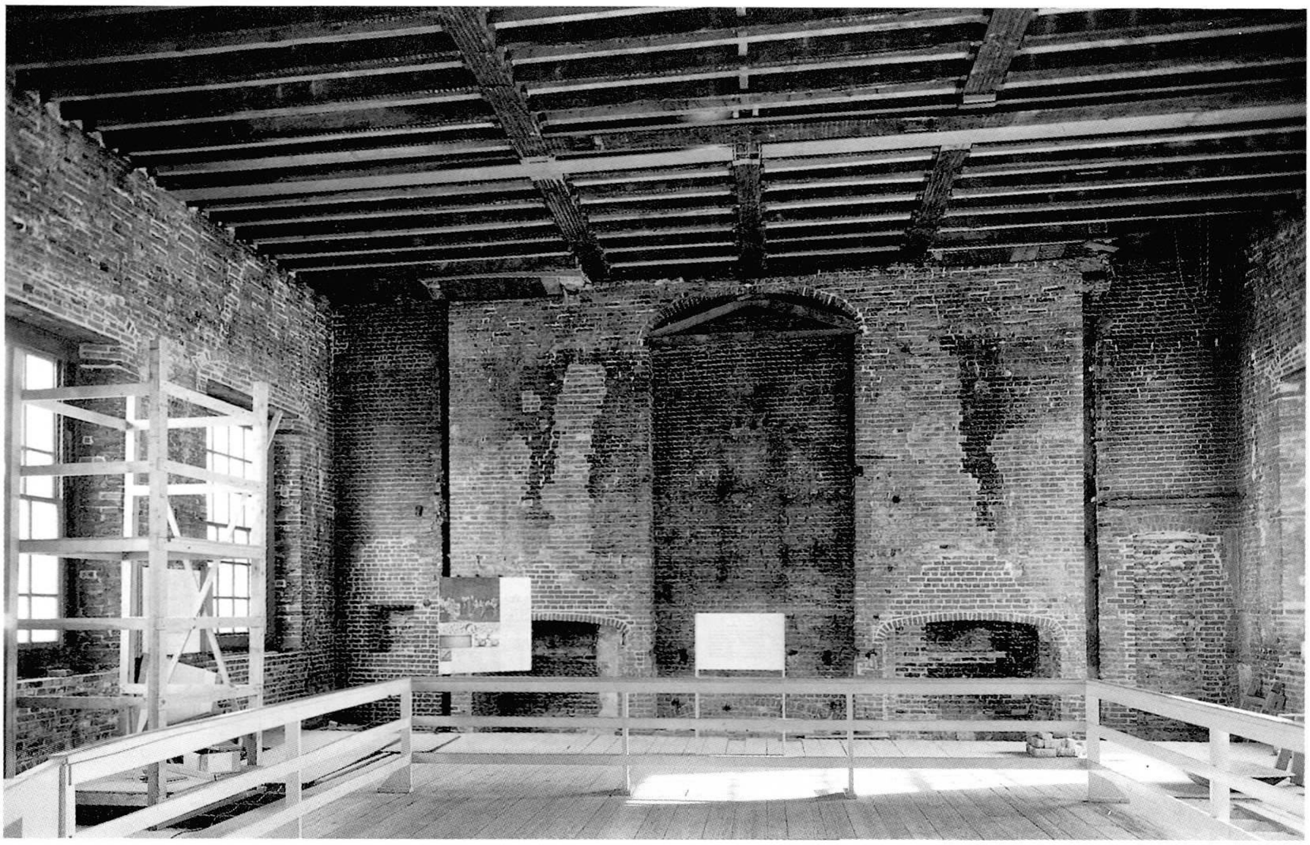
The scope of the preservationist's concerns has long ago progressed from the preservation of an isolated aristocratic house and garden to the conservation of whole districts and, indeed, to entire towns; and from wholly urban sites to suburban and even rural ones. We have come to understand the equal importance of all styles of building, folkloristic and vernacular, as well as monumental and high style. And by the same token, we have broadened our definitions of historicity as extending from pre-Columbian dwelling sites to significant skyscrapers as recent as New York's Lever House and Seagram Building. In other words, willy-nilly and without our willing it, the jurisdiction of historic preservationists has broadened to awesome dimensions: curatorship of the whole built world.

For an audience such as this, it will not be necessary to belabor the analogies between preservationist's efforts to save the man-made world and the struggles of the environmental conservancy movements to save the God-made. Here, too, the field of action has steadily broadened from local skirmishes to save Walden Pond or California redwoods, to international campaigns to conserve whole ecological systems like the tropical forests of the Amazon or northern Quebec from the giant Hydro-Quebec project which threatens to flood its northern half and wipe out the native Cree and Inuit peoples. Such fields of action, by historic preservationists and conservationists of Nature, are so far only parallel, symbiotic. But of course they are rapidly becoming fused in the much larger issues of the carbon dioxide mantle (which threatens the earth with the dreaded "green house effect") and the hole in the ozone layer (which protects all life on earth from solar radiation) -- both of which threaten the earth itself.

The growing interest of modern urban man in his past, in artifacts of antiquity, in old cities and gardens, seems to me an expression of his growing sense of alienation in his radically changing personal environment. Man had developed across millennia in environments which offered him a dynamic equilibrium between *stasis* and change.

* James Marston Fitch. Historic Preservation: Curatorial Management of the Built World. University of Virginia, Charlottesville, Va., 1982.

Mount Vernon, Virginia, Home of George Washington. Restoration begun 1859. Shown above, aerial view of mansion and grounds as restored to 1799, date of Washington's death.



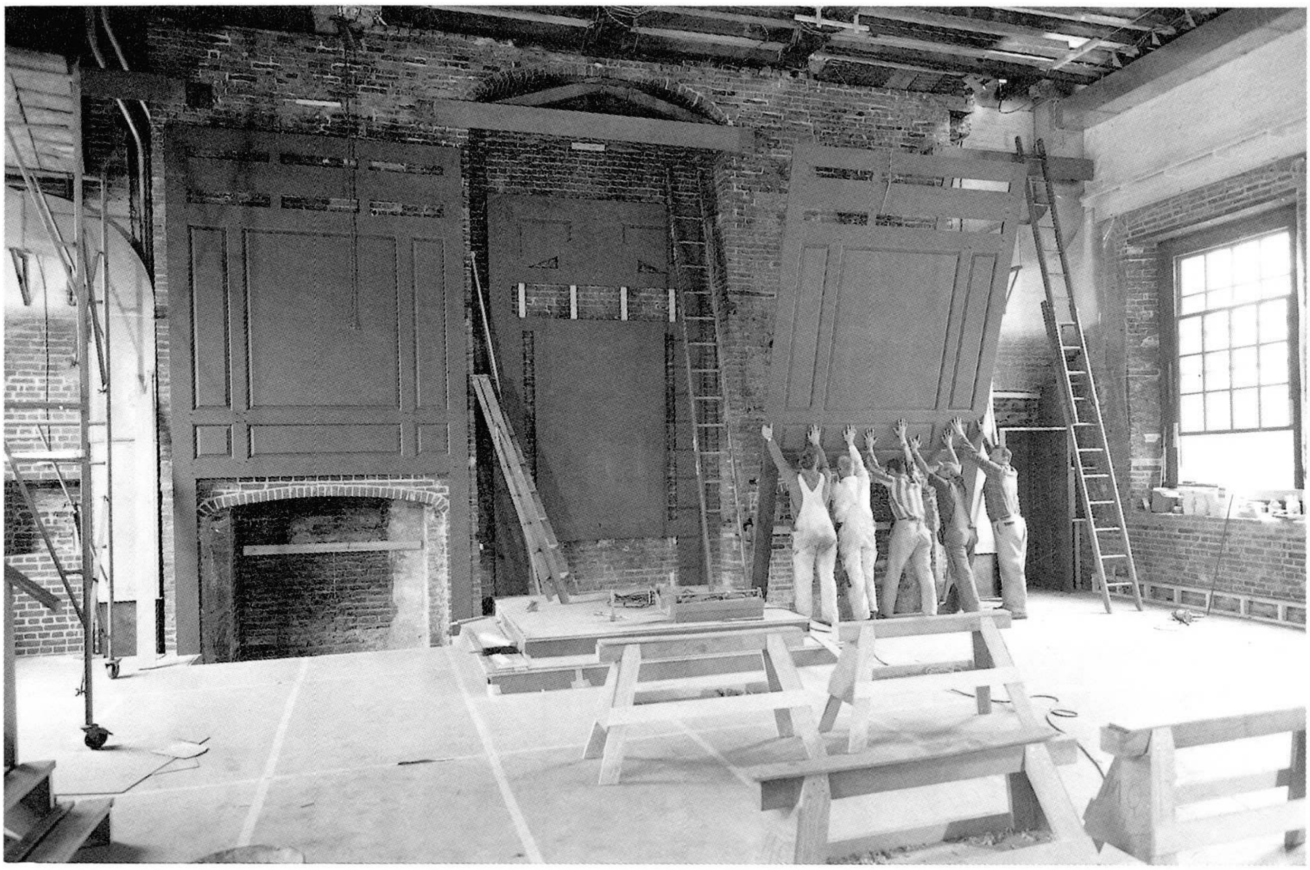
Independence Hall, Philadelphia, Pennsylvania. Restoration completed 1976. Shown here, Assembly Room (where Constitution of the United States was signed) after structural consolidation.

Archaeology shows us that there had always been change in human society; but the rate of that change had been too slow to have been perceptible to the individual. Environmental changes were seldom large or rapid enough to be stressful to the ancient societies which caused them -- e.g. the deforestation and desiccation of the Italian peninsula by the wood-burning brick and tile industries of Imperial Rome. But the rate of change, and hence of environmental degradation and habitat destruction, began to accelerate with the Industrial Revolution of the late eighteenth century. It has been accelerating ever since until today it effects the personal environment of every man on earth. And, ironically enough, the very instruments with which the brave new world was built -- steam engine, electric motor and internal combustion engine -- are now seen as the causes of the world's most profound environmental crisis; waste gases from the burning of fossil fuels, causing the greenhouse effect; waste gases from the compressors destroying the ozone.

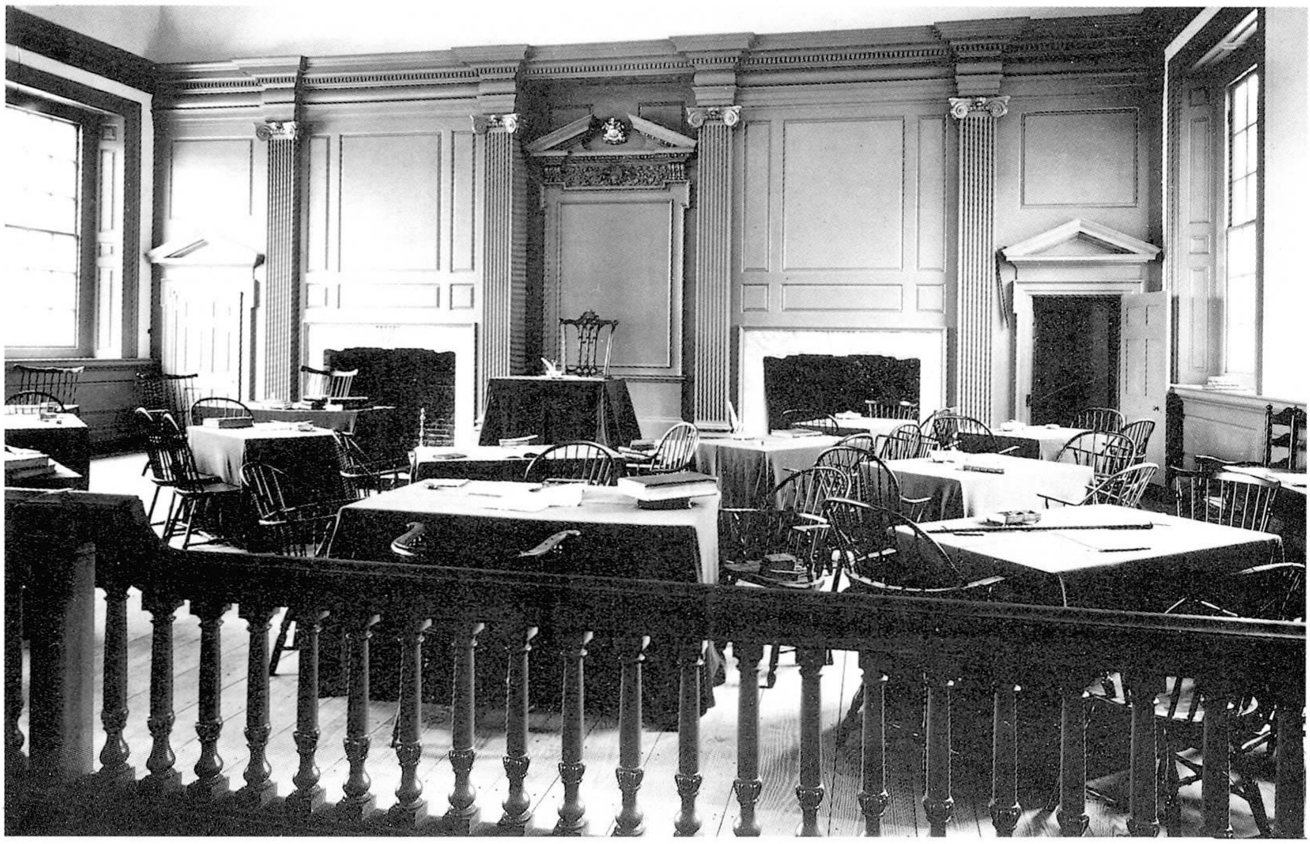
The American preservation movement was to grow immensely in size and influence in the years after World War II. Though in the process it attracted increasing support from professionals -- architects, landscapists, planners, art and architectural historians -- its membership has remained overwhelmingly a party of lay persons. (And, it must be added, overwhelmingly feminine though for reasons which so far no one has undertaken to explain.) This lay membership has been cool if not actually hostile to its new allies from the professions; a distrust which undoubtedly sprang from the fact that the preservationists have all too often seen architects, engineers and planners as the principal spokesmen for the very forces of self-styled "progress" which threatened the historic structures in their communities, which they were fighting to preserve. This tension has tended to abate somewhat in recent years, largely because of change in the perception of the design professionals themselves. In any case, it is the preservationists who must be credited with a radical change in the climate of American opinion towards historic buildings and, indeed, towards the past itself.

If there is one point about which preservationists have always been united, it is on the absolute uniqueness of the original artifact. If they sometimes have mistaken the identity or provenience of the artifact they venerated, it was always due to faulty scholarship or flawed research, never to malice or mendacity. The local battles of the preservationist have always been to save the actual -- the bed in which Lincoln died, the tree beneath which Washington saw the battle of Stony Point, the pond beside which Thoreau wrote his essays. They have seldom accepted a facsimile as an acceptable surrogate for the real thing. Sometimes the only way to save the historic building has been to move it to a less perilous site, like the outdoor architectural museum. Or to move selected rooms of the historic house being threatened with demolition to the controlled climate of an art museum. But there are few instances indeed where preservationists have erected three-dimensional facsimiles on the site of vanished originals -- if for no other reason than that such replicas were beyond their means. Thus, the Williamsburg reconstruction of the long-vanished Capitol and Governor's Palace must be seen as the exception, not the rule, in preservation practice.

There is, of course, another way of quantifying the value of the built world; and that is in terms of the huge deposits of energy which it represents. Embodied energy is the term now used to describe all the activity, human and mechanical, required to produce any artifact, from a brick to a building. Thanks to computer technology, it is now quite



Independence Hall, Philadelphia, Pennsylvania. Restoration completed 1976. Shown here, Assembly Room: reinstallation of original paneling.



Independence Hall, Philadelphia, Pennsylvania. Restoration completed 1976. Shown here, Assembly Room: interior restored to 1776 condition.

practicable to quantify such energy deposits, not only for the man- and machine-hours expended on site in the construction of a building, but also for all energy expenditures back through transportation to factories, steel furnaces, brick kilns, saw mills, iron and coal mines, clay pits, etc. Such cost accounting expresses building costs in terms of BTUs rather than dollars-and-cents. And the results are often astonishing. Thus, in one study comparing energy costs of two new, similar office building structural systems -- one employing energy-intensive steel framing, the other using a low-energy concrete system -- the researcher found that though the dollar costs were roughly equal, energy costs in the steel system ran 32% higher than the concrete one.[1]

As we shall shortly see, in one of our case histories, there are great energy economies in the rehabilitation and adaptive reuse of old buildings. Since such projects are even now competitive with new construction, in conventional dollar terms, it is obvious that an accounting for the embodied energy conserved in preservation clearly makes them more advantageous; and even more so when we take into account the energy cost of the demolition of the old building and its carting away for nothing more productive than landfill. Such a new style cost-accounting would reveal an enormous waste of energy in the wholesale demolition of old buildings -- all the more appalling environmentally since it could only be accomplished by motorized equipment burning fossil fuels. American architects and planners have been guilty of two conceptual errors in handling the historic fabric of our country: they saw their task as being that of constructing an exclusively new built world; and -- flowing out of this misconception -- a frightening neglect of (if not, indeed, contempt for) the already-built world. The planners have been especially guilty of this conceptual posture, forgetting both the past and the present in their sponsorship of the "urban renewal" programs of the 1950s and 1960s, which came so near to destroying many American cities altogether. I am not suggesting that the crisis of the built world can be solved without the full participation of architects and planners; they will be essential members of any team which will be able to rescue us from environmental disaster. But they have to purge themselves of recent error: the planners must understand that they cannot handle the future until their feet are firmly planted in the present; the architects understand that they cannot meet the ineluctable demands of history with the historicizing eclecticism of Post Modernist pastiche.

The preservationists, whatever their shortcomings, have always been site specific almost by definition. It used to be popular to accuse them of parochialism -- "little old ladies with blue hair and tennis shoes" -- whose sole preoccupation was protection of George Washington's last sleeping place or Abe Lincoln's birthplace. But time has proved this estimate quite wrong. In those American cities whose centers have been saved from the evisceration of urban sprawl and returned to viability, it has been precisely the ethos of preservation which has proved to be the energizing force. In Portland, Maine; Boston's North End; Philadelphia's Society Hill; Baltimore's Harbor; in the conversion of the historic centers of Charleston and Savannah from slums into major touristic resources; in San Antonio with the conversion of a muddy little river into one of the beauty spots of the Southwest; in San Francisco, where the preservationist ethos has capped the height and number of skyscrapers and is now

1 The Stein Partnership, Handbook of Energy Use for Building Construction, U.S. Department of Energy, Washington, D.C., 1981. pp.83-85.

Ellis Island, New York Harbor. Aerial view of the with Manhattan Island in the background. Restored Registry Building is at lower center of photo.

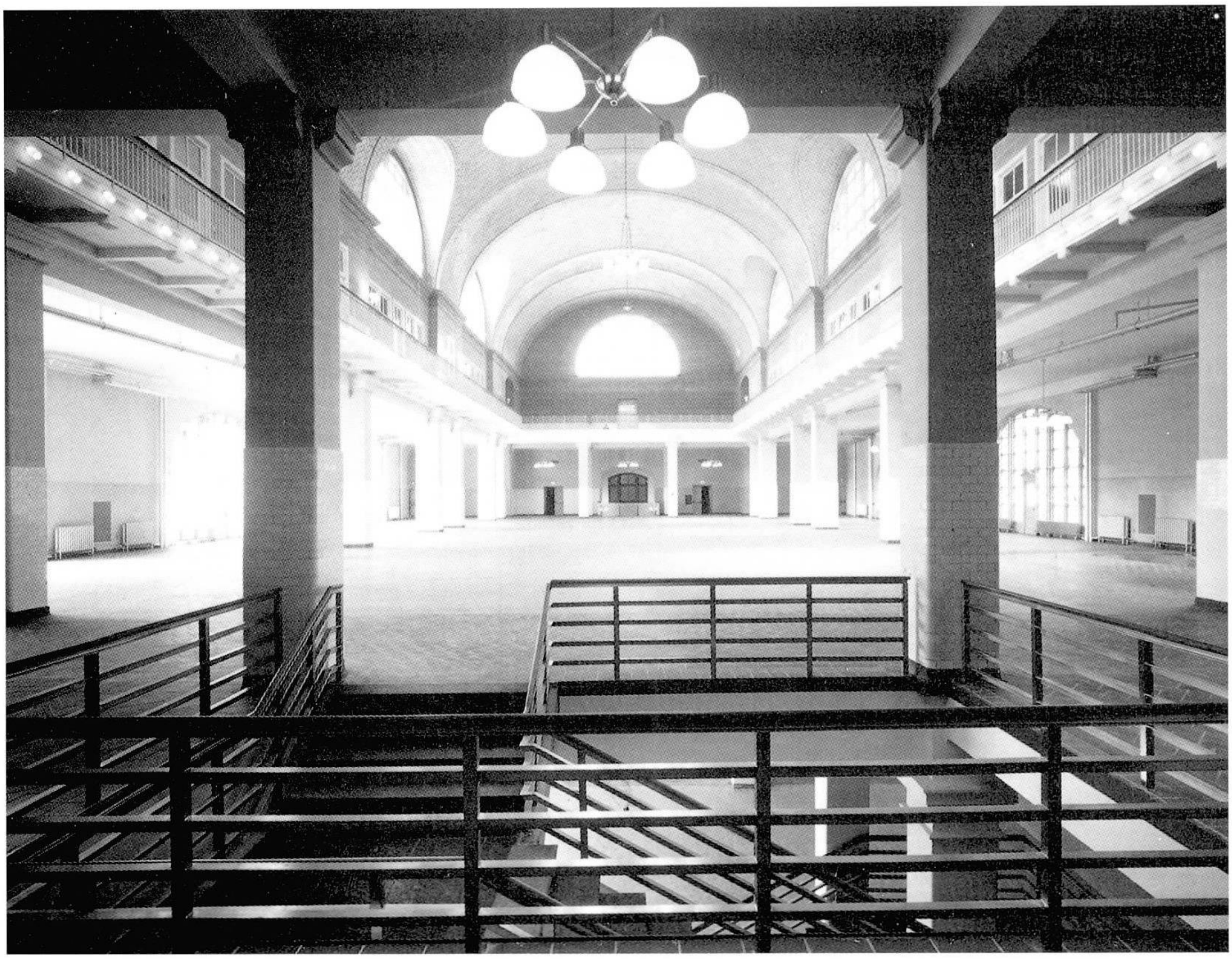
Ellis Island, New York Harbor. 1922 view of Registry Room with immigrants awaiting physical examinations prior to admission.

forcing the demolition of the elevated highway which cut the city off from its harbor front; even in those Midwestern cities where urban attrition was most ferocious -- St. Louis, Cincinnati, Kansas City -- preservation is helping to knit together the damaged urban fabric. And, far from having preserved only those historic buildings which have survived, district preservation has always generated impressive amounts of brand new buildings. I do not mean to suggest, of course, that we should never demolish an old building or never construct a new one. But rather that, as curators of the built world, preservationists should insist on a new type of environmental bookkeeping, in which the true costs of energy expenditure is calculated in all projects involving extant buildings, historic or simply old.

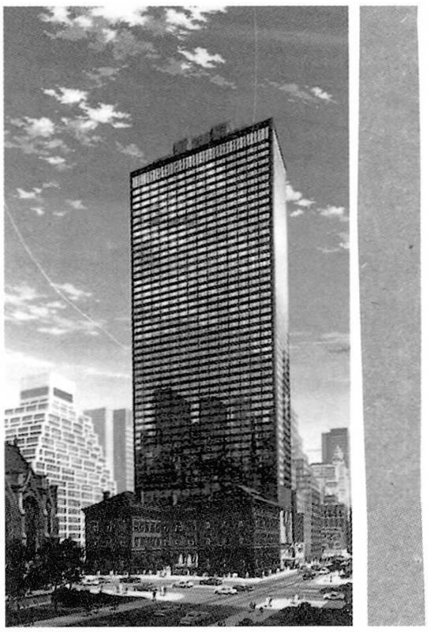
The recent history of the preservation movement has been marked by the steady increase in its professional expertise, including closer contacts with the adjacent fields of historical archaeology, art history and art conservation. It has also been characterized by such institutional developments as The National Trust for Historic Preservation, with its large national staff and mass membership. Most significantly, some ninety colleges and universities have introduced courses in the subject, 29 of them offering graduate degrees. These schools have by now produced some 2,500 alumni and established their own professional body, the National Council for Preservation Education. The 25-year old Association for Preservation Technology boasts some 2,500 members in chapters in the USA and Canada and publishes the authoritative *APT Review*. Both the Society of Architectural Historians and the American Institute of Architects have national and local preservation committees. In addition, there is the independent academic publication, *Technology and Conservation* of Cambridge, Massachusetts.

American experience in preservation has led to the conclusion that we must think of the artifacts with which we deal -- cities, districts, individual buildings -- as living organisms. Then it becomes apparent that they display all the pathological processes of life, including that of simple aging, and that therapeutic interventions will necessarily cover a wide spectrum of treatments, from the conservative to the radical. The medical analogies are not at all farfetched. Specialized problem areas are already being described as "stone disease," "glass disease," and effect which must be understood before a successful therapy can be undertaken. And again, as in medicine, the most conservative treatment possible in any given case is usually the wisest, if for no other reason than that it is most easily reversed: least done, soonest mended. Reversability is a criterion which has developed from a century's experience in archaeology and art conservation, where radical interventions employing the "latest thing" in science and technology have often led to the irreversible degradation of the artifact in question. We can therefore classify levels of intervention according to a scale of increasing radicality: 1) preservation; 2) restoration; 3) conservation and consolidation; 4) reconstitution; 5) adaptive reuse; 6) reconstruction; and 7) replication.

Preservation implies the maintenance of the artifact in the same physical condition as when it was received by the curatorial agency. Nothing is added to or subtracted from the aesthetic corpus of the artifact. Any interventions necessary to preserve its physical integrity (e.g., protection against fire, theft, or intrusion; heating, cooling, lighting) are to be cosmetically unobtrusive. Examples: Franklin Delano Roosevelt Home, Hyde Park, New York; Wavel Palace, Warsaw, Poland.



Ellis Island, New York Harbor. Registry Room after restoration, as part of newly opened Museum of American Immigration.



Two views of **Palace Hotel with Restored Villard Mansions, New York, N.Y.,** in foreground.

Restoration describes the process of returning the artifact to the physical condition in which it would have been at some previous stage of its morphological development. The precise stage is determined either by historical association (the way it was when Washington slept there) or aesthetic integrity (the portico at Mount Vernon must have *all* its columns). Intervention at this level is more radical than simple preservation. Examples: Mount Vernon; Monticello.

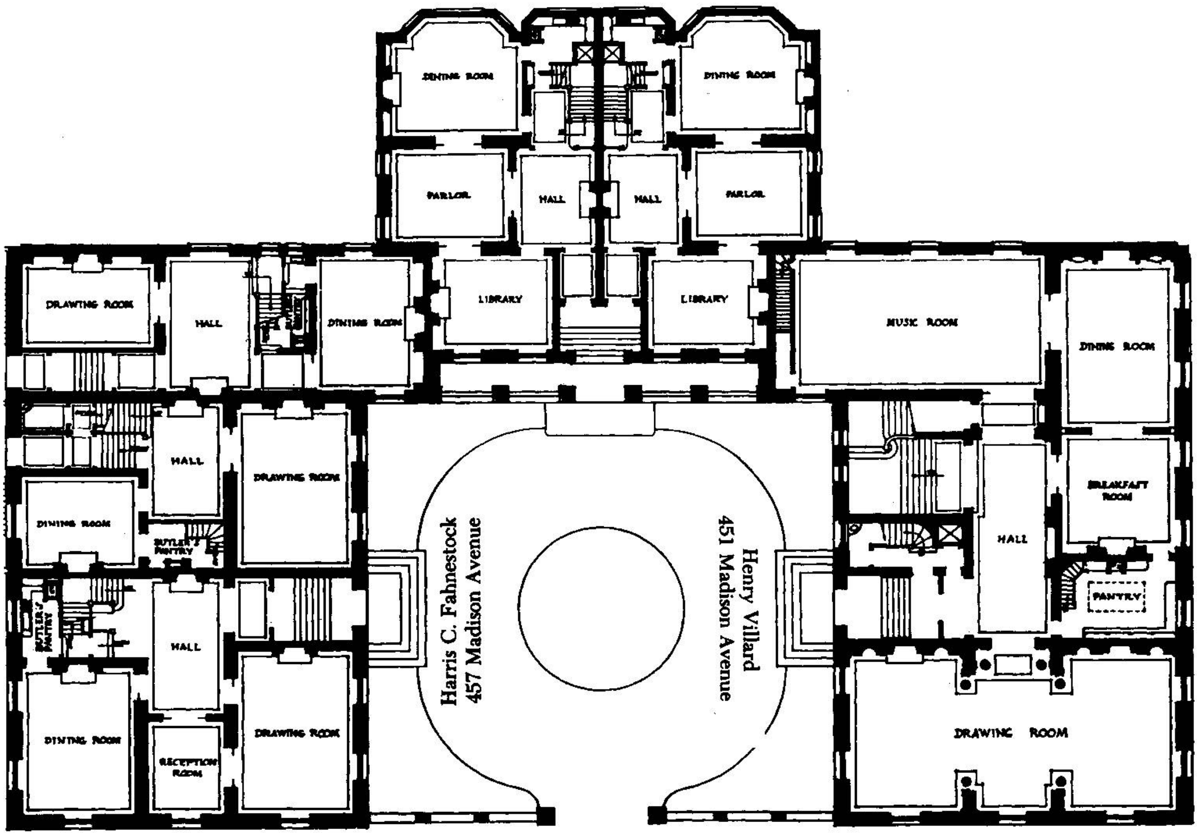
Conservation and Consolidation describes physical intervention in the actual fabric of the building to ensure its continued structural integrity. Such measures can range from relatively minor therapies (fumigation against termites, Royal Palace, Honolulu; stone cleaning, Notre Dame, Paris) to very radical ones (consolidation of desiccated wood, Vasa warship, Stockholm; insertion of new foundation, York Minster, England).

Reconstitution is a more radical version of the above, in which the building can be saved only by piece-by-piece re-assembly, either in situ or on a new site. Reconstitution *in situ* is ordinarily the consequence of disasters such as war or earthquakes, where most of the original constituent parts remain in being but *disjecta*, or scattered (Cathedral of Antigua, Guatemala; Bridge of Santa Trinita, Florence). On occasion, it may be necessary to dismantle a building and reassemble it on the same site (Old State Capitol, Springfield, Illinois.) Reconstitution on new sites is now familiar, usually the consequence of the transplanted structure being too big or bulky to have been moved intact. Examples: Old Bethpage Village, New York; St. Mary Aldermanbury, Fulton, Missouri.

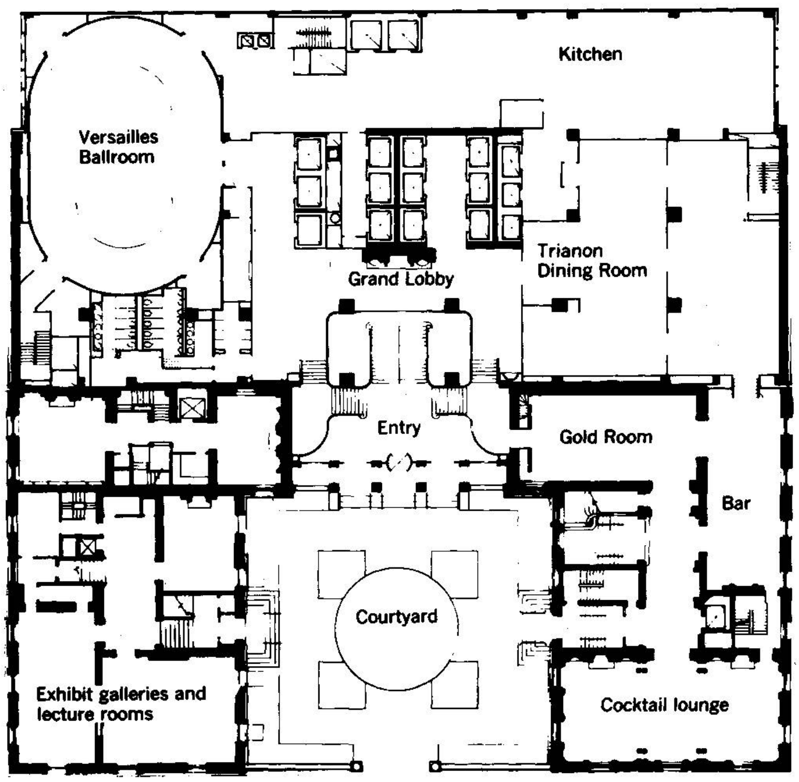
Adaptive Use is often the only economic way in which old buildings can be saved, by adapting them to the requirements of new tenants. This can sometimes involve fairly radical interventions, especially in the internal organization of space, in which any or all of the above levels of intervention may be called for. Examples: Castello Sforzesco, Milan; Old City Hall, Boston; "Chattanooga Choo-Choo," Chattanooga.

Reconstruction describes the re-creation of vanished buildings on their original site. The reconstructed building acts as the tangible, three-dimensional surrogate of the original structure, its physical form being established by archaeological, archival, and literary evidence. This is one of the most radical levels of intervention. It is also one of the most hazardous culturally. All attempts to reconstruct the past, no matter what academic and scientific resources are available to the preservationist, necessarily involve speculative hypotheses. In historiography, such hypotheses can be (and indeed are) constantly revised; in architecture, the hypothesis is obdurate, intractable and not easily modified. Examples: Royal Palace, Warsaw, Poland; Governor's Palace and House of Burgesses, Williamsburg; Stoa of Attalos, Athens; Iwo Treasure House, Japan.

Replication in the art field implies the creation of a mirror image of an extant artifact. In the case of architecture, it implies the construction of an exact copy of a still-standing building on a site removed from the prototype. In other words, the replica coexists with the original. Physically the replica can be more accurate than the reconstruction, since the prototype is available as a control for proportion, polychromy, texture. It is at once the most radical and the most hazardous of all forms of intervention; nevertheless, it has specific utility in certain situations, e.g., to stand in the open air as



Plan of old **Villard Mansions** before erection of new **Palace Hotel.**



Plan of **Palace Hotel** with new lobby across top and converted **Mansion** rooms around court, at bottom.

a surrogate for an original which must be moved to the controlled environment of a museum. Examples: the Caryatids, Erechtheon, the Acropolis, Athens, Greece; Plimoth Plantation, Massachusetts; Getty Museum, Malibu, California.

Since the private sector has played such a prominent role in American preservation, economic feasibility has been an important factor in many projects. Thus it is not surprising that many of our projects involve adaptive re-use. I have been asked to deal with this in today's lecture: because of limitations of time and space I shall confine myself to four outstanding examples.

The Palace Hotel, New York, New York

The preservation of the Villard Mansions -- a group of late-nineteenth century townhouses designed as a unit in the years 1884-1886 -- has been adapted for use as the lobby and reception rooms of the new 40-story Palace Hotel which was erected immediately behind them. An interesting architectural accomplishment in itself, the project is even more significant urbanistically, however, since it consolidates and extends the spatial envelope created by St. Patrick's Cathedral opposite it across Madison Avenue. This huge aerial bubble of space extends, in turn, to Rockefeller Center Plaza a block away to the west; and to Mies van der Rohe's splendid Seagram Tower with its be-fountained plaza to the east; and finally to the great United Nation's complex further east on the East River, thus creating a huge window to the open sky in one of the most dense concentrations of skyscrapers anywhere on earth. The monumental parlors, libraries and dining rooms of the Villard's former mansions have been skillfully restored and adapted for use by the hotel and for other cultural institutions and specialized shops. The courtyard has been elegantly landscaped to serve as a pedestrian entrance to the entire complex. An historic complex of great significance to mid-town Manhattan has thereby been given a viable new economic basis for its otherwise jeopardized position. The architects were Emory Roth & Sons of New York City.

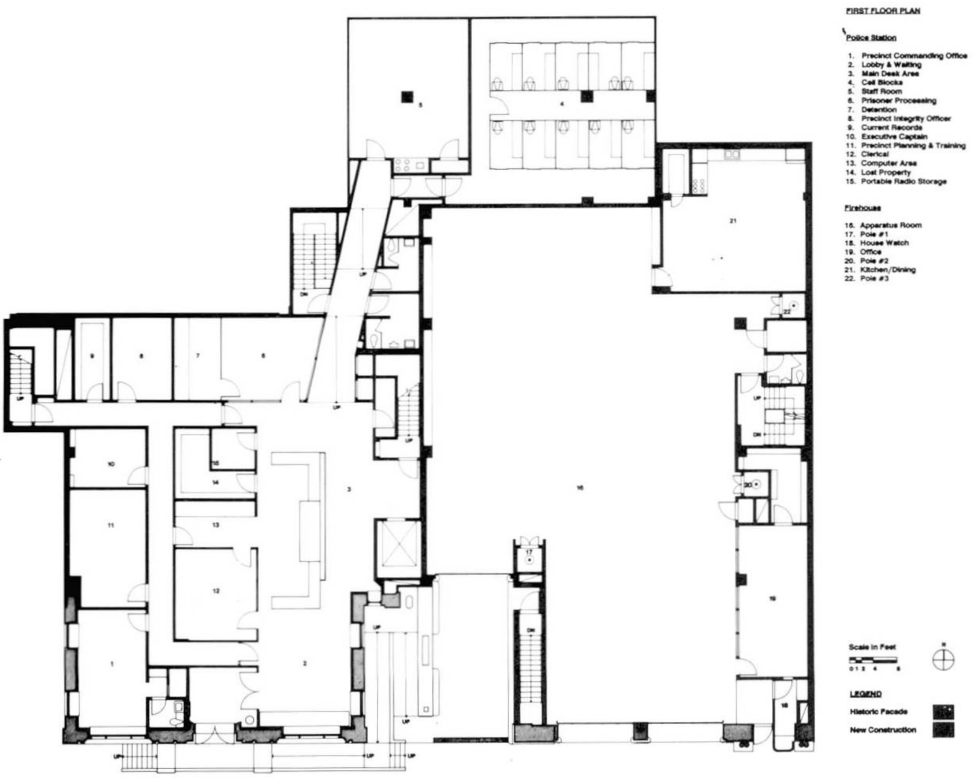
Combined Police/Fire Engine Stations, New York, N.Y.

Two late-nineteenth century buildings, with ornate Victorian facades and load-bearing masonry walls, a century later still housed the police and fire stations for which they had been originally built. Located on the Upper East Side of Manhattan and long obsolete, their demolition had been prevented by the neighborhood's affection and then by Landmark designation; and their modernization had been stalled for decades by building and fire codes, foundation problems, etc. This imbroglio was finally broken when, in 1982, the decision was made 1) to preserve and restore the designated historic facades, 2) to completely reconstruct the complex facilities behind them in modern fireproof construction, and 3) to re-establish the police and fire-fighting services which had continuously occupied them. The immaculately conserved facades along with their flanking neighbors (an 1890s Dispensary and a circa 1886 Jewish synagogue) constitute a unique block-long collection of exuberant Victoriana much cherished by New Yorkers. The architects were The Stein Partnership of New York.

Museum of American Immigration, Ellis Island

Museum of American Immigration, Ellis Island, New York, New York. Ellis Island, standing in New York City's harbor almost in the shadow of the Statue of Liberty, was the main port of entry for the millions of immigrants who poured into the country in the first third of this century. While it grew from small and almost accidental

Restored Historic Facades of Fire Station and Police Station, New York, N.Y. Brick and limestone trimmed facade carefully returned to their original 1885 condition.



Restored Historic Facades of Fire Station and Police Station, New York, N.Y. Partial plan.

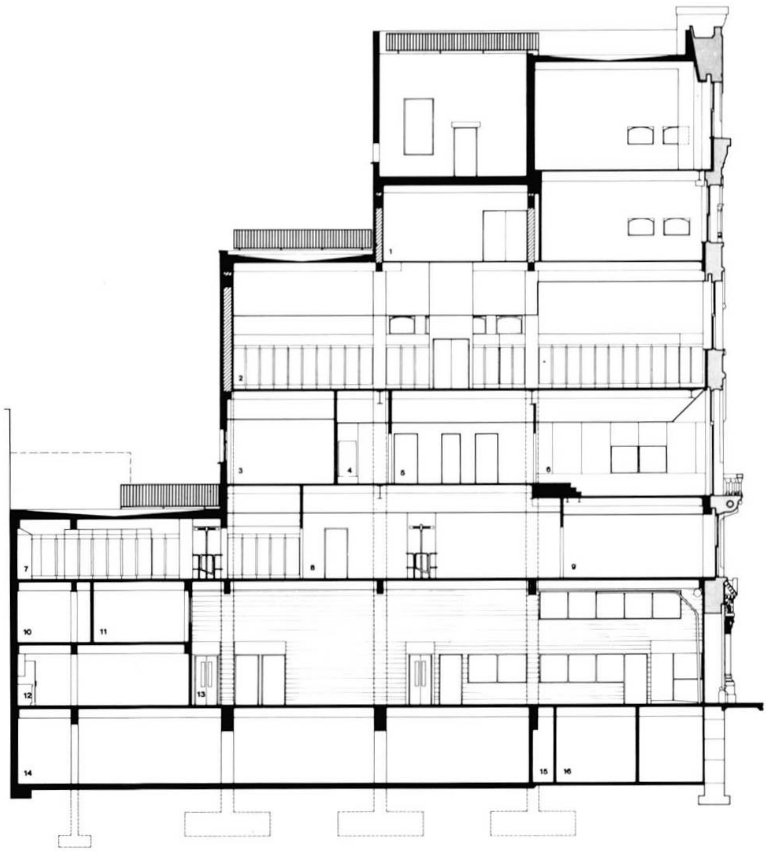
beginnings, the institution and indeed the little island on which it stood steadily expanded until 1923, when the U.S. government switched to the visa system of screening immigrants at the ports of their departure. This robbed Ellis Island of its screening function and there began a long steady slide into decline. From 1950 until 1980, it was largely unoccupied when the decision was made by the U.S. National Parks Service to make it into the Museum of American Immigration. The great Beaux Arts Reception Center was selected not only to house the new museum, but to become, itself, the Museum's greatest exhibit. Thus, while new amenities have been incorporated (two new theaters, a restaurant, escalators, a bookstore, etc.) most of the building has been meticulously restored to its circa 1918 condition including furnishings and equipment in such areas as dental clinics, mess halls, baggage rooms, ticket booths. Even the original morgue has been preserved along with some of the thousands of poignant *scraffiti*, scratched in the plaster by despondent immigrants. These have been preserved *in situ* or moved into appropriate displays. Although only the Reception Center complex has so far been restored, the entire 28 acre island is scheduled for ultimate development. The architects were the firms of Beyer Blinder Belle of New York and Notter Finegold & Alexander of Boston.

The Audubon Society Headquarters, New York, N.Y.

The most sophisticated of recent American restoration projects is the new home office of the National Audubon Society in New York City. As one of the nation's oldest agencies dedicated to the conservation of Nature, the Audubon Society decided to make its new headquarters an exemplar of energy conservation. Instead of building *de novo*, they decided to buy a century-old office building in an historic district and retrofit it to the high levels of environmental effectiveness. They would be conserving energy at three different levels: (1) the billions of BTUs of energy embodied in the fabric itself and the additional BTUs of energy required to demolish it and cart it away; (2) the added billions of BTUs of energy required to construct a brand new building; and (3) the savings in operational costs to be obtained from the high level, user-friendly retrofitting.

To avoid the "sick building syndrome" so common in many of today's sealed-window, air conditioned skyscrapers, the retrofitted Audubon Society Headquarters employs many energy-saving and health-protecting features. The large mass and huge volumes of the century-old building are employed by the heating, ventilating and air conditioning engineers as a "thermal balance wheel" against the New York climate, with its wide diurnal and thermal oscillations. As a thermal shell, the efficiency of the load-bearing masonry walls has been raised to a coefficient of R-14 by a mix of magnesium and sea water and its roof raised to R-36 by a more orthodox mattress of fiberglass. The year-round air conditioning itself is gas-powered, draws fresh air from the 9th floor penthouse, provides 6.3 air changes per hour (as against 4 changes per hour required by code), and filters 80% of airborne particulates (as against 30% called for by the American Society of Heating, Refrigeration, and Air Conditioning Engineers' standards). The new windows have insulating glass and a heat-rejecting inter-layment which admits solar heat in winter and excludes it in summer. Most notably, the sash are all easily opened from the offices.

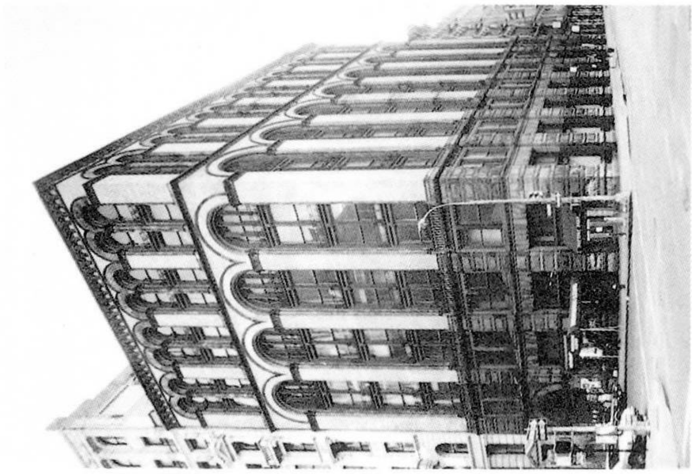
Externally, the red sandstone and terra cotta building has been handsomely restored to its original state. The interiors -- which had long ago been stripped of their



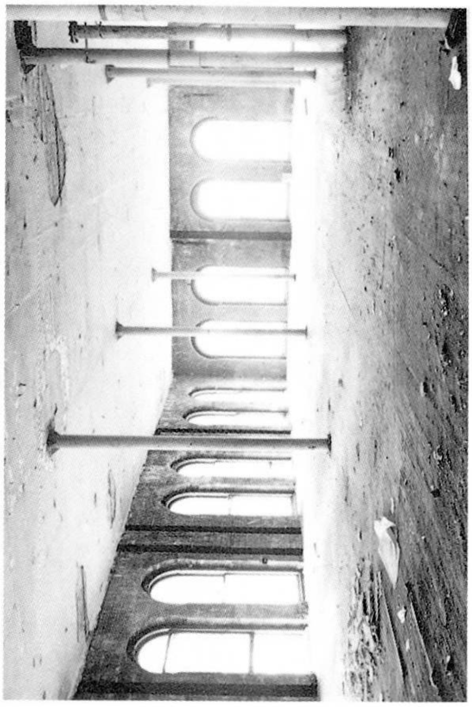
Restored Historic Facades of Fire Station and Police Station, New York, N.Y. Partial section.

Restored Historic Facades of Fire Station and Police Station, New York, N.Y. Brick and limestone trimmed facade, heavily damaged by a century of exposure.

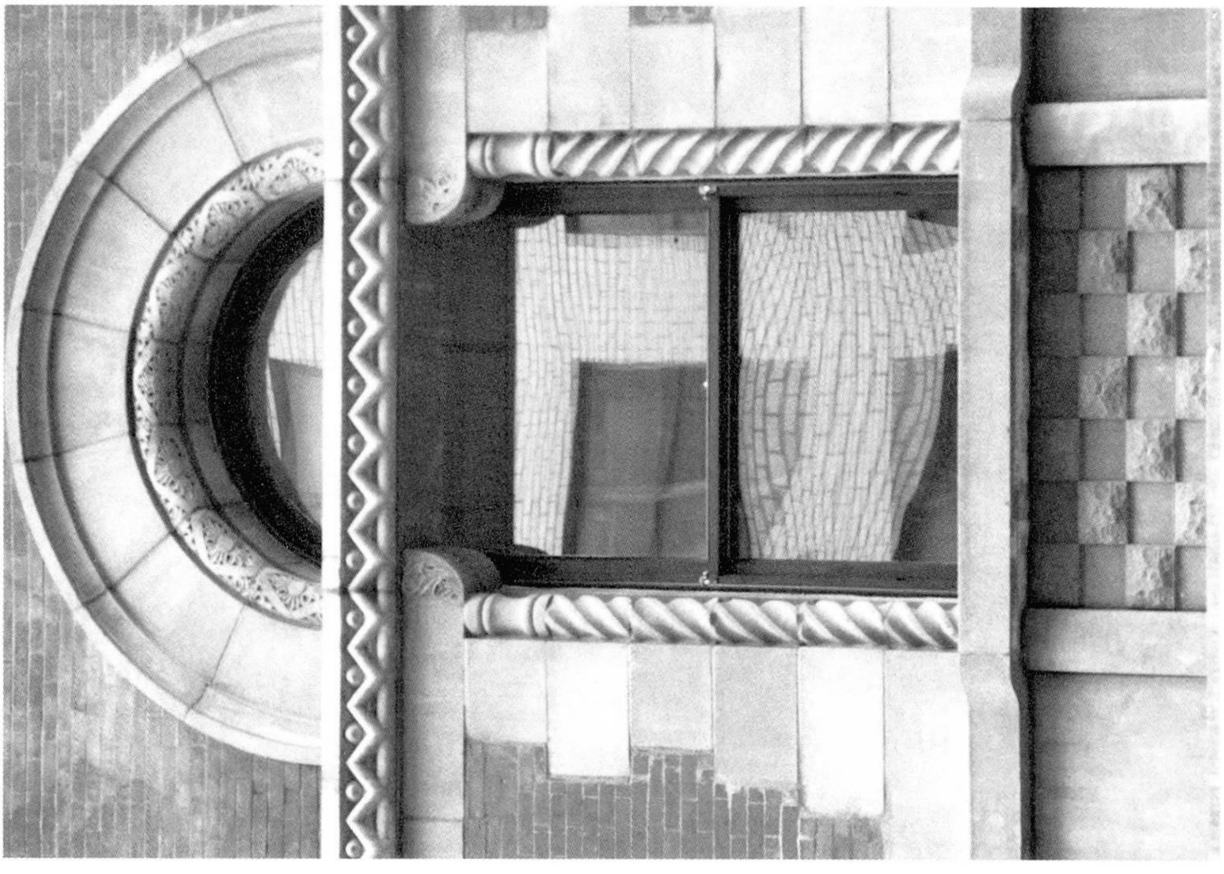
Headquarters of the Audubon Society, New York, N.Y.



Interior after restoration.



Interior before restoration.

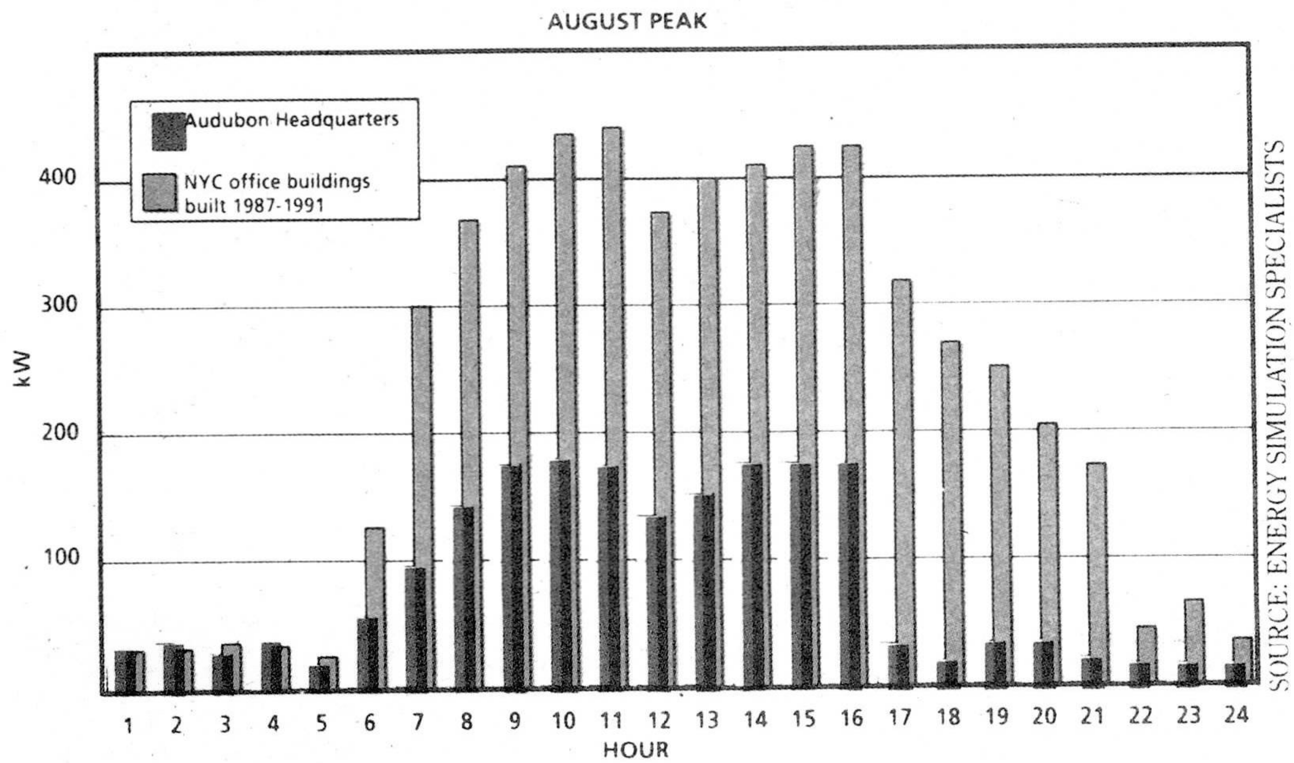


Restored Historic Facades of Fire Station and Police Station, New York, N.Y. Brick and limestone trimmed facade carefully returned to their original 1885 condition.

department-store fittings -- have been completely redesigned as modern offices, with integral new furniture and high efficiency lighting. To minimize air pollution by toxic chemicals from plywood, plastic tiles, synthetic carpets and underlayments (e.g., formaldehyde, benzine, carbon monoxide, etc.), all natural materials, such as undyed cottons, wool carpeting, and natural jute underlayment, have been employed.

The results have proven highly satisfactory. The purchase of the old building ran to $10 million. Complete restoration and recycling ran to $14 million more -- this for a building which would have cost about $33 million at current rates. The Society counts on $100,000 per annum savings in energy costs as well as other savings in insurance and taxes, and leasing of newly renovated commercial spaces. Finally, the restored building acts as an important anchor to the historic district of which it is a part.

PEAK ENERGY USE:
AUDUBON'S HEADQUARTERS VS. TYPICAL NEW NYC OFFICE BUILDING



Leere Seite
Blank page
Page vide

Panel Discussion

Information Systems for Monuments and Historical Buildings

Systèmes d'information pour les monuments et bâtiments historiques

Informationssysteme für historische Bauten

Leere Seite
Blank page
Page vide

Information Systems for Monuments and Historical Buildings

Systèmes d'information pour les monuments et bâtiments historiques

Informationssysteme für historische Bauten

M. FANELLI
Professor
ENEL-CRIS
Milano, Italy

M. Fanelli, born in 1931, obtained his Civil Eng. degree cum laude in 1954. Concerned with computer analysis of structural and hydraulic problems, he is now director of CRIS of ENEL.

SUMMARY

The drawbacks of traditional approaches to information management and treatment for historical buildings are reviewed, and the opportunities and advantages offered by systematic application of modern information science tools are illustrated. The possibilities of an organized effort aimed at taking the first steps in this direction are also briefly discussed.

RÉSUMÉ

L'auteur montre les limites de l'approche traditionnelle à l'organisation et au traitement des informations pour les monuments historiques; il indique les avantages d'une application des outils modernes fournis par l'informatique et propose les premières approches concrètes dans cette direction.

ZUSAMMENFASSUNG

Die Nachteile traditioneller Vorgehensweisen bezüglich Datenverwaltung und Behandlung historischer Gebäude werden einer Revision unterzogen. Die durch eine systematische Anwendung dieser modernen Informatikmittel sich bietenden Vorteile werden beschrieben. Die Möglichkeiten gemeinsamer Bemühungen, mit dem Ziel erste Schritte in diese Richtung zu unternehmen, werden ebenfalls kurz besprochen.

1. GENERAL.

Quite too often, studies on safety and preservation of monumental buildings are subjected to serious shortcomings stemming from the lack of proper information, or from the poor quality and organization of existing documentation.
Indeed, not only are historical monuments often insufficiently documented, from an engineering or from the architectural and even geometric point of view; it also happens that previous experiences in the field, which could bring precious contribution or inspirations to the treatment of the particular problem in hand, are not known (or, again, not adequately documented) and thus go unnoticed, with serious economic and/or technical drawbacks, including repetition of efforts and errors, unnecessary loss of time, costs of un-needed expertise etc.
Yet, simply to mention a single one among the topics which could be selected for discussion, the modern tools of informatics provide the possibility of mounting a rational effort toward making all the relevant knowledge, accumulated about particular buildings, or about particular classes of problems, properly documented and recorded in object - oriented data bases.
If this goal were achieved, the door would be open to easy access by all concerned parties, and the experience gained from each single case-history would integrate those from other similar applications, with important synergistic effects. The appropriateness (or otherwise) of applying certain methodologies to certain classes of problems could be highlighted by automatic selection through proper query languages, and so on.
More generally, the possibilities offered by contemporary information Science open up a vast spectrum of choices and opportunities, as appears from the following outline.

2 - OUTLINE OF IMPORTANT POINTS FOR DISCUSSION:

2.1- (General)

Critical attention should be devoted to detailed examinations of the depth of penetration of information technologies.
In particular one should identify and discuss the numerous drawbacks of presently used traditional procedures, such as e.g. slowness, difficulty of information retrieval, obstacles to diffusion and cross-reference of information, etc.
From this recognition of insufficiency of traditional approaches, one should then more clearly appraise the necessity of using the large possibilities of informatics for easy access to relevant data sets.

2.2- (Detailed discussion of areas where informatics could provide signal advantages):

2.2.1 On-line monitoring and "safety control" of monuments. It should be noticed that these systems, given significant installation and operating costs, are in fact conceivable only for important structures; what to do for lesser ones?;

2.2.2 Numerical models for:

- assessment of safety under normal and exceptional loads;
- measurement interpretation; identification;
- diagnostic of damage, trend analysis;

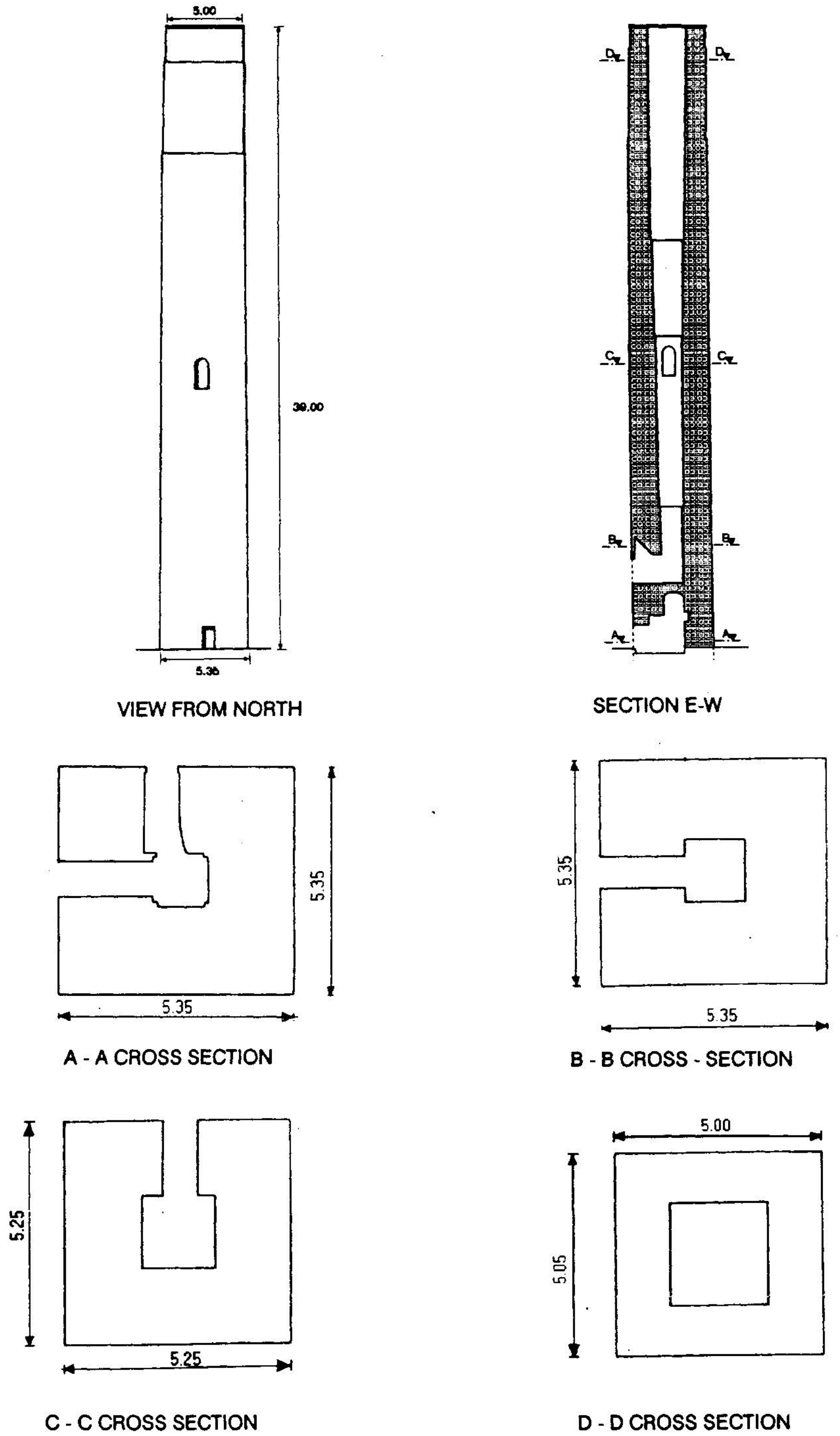


Fig. 1 - Traditional documentation for a masonry tower.

- forecasting and hindcasting of intervention effectiveness; objective comparison of different intervention alternatives;

2.2.3 Data-bases containing and updating all relevant information about individual monuments, e.g.:
- present geometric definition;
- history: modifications, additions, repairs, construction methods and materials, exceptional events, etc;
- mechanical properties: densities, Young moduli, Poisson's ratios, damping factors for above-ground structural materials; geotechnical and geomechanical properties for foundation materials;
- structural static and dynamic in-situ measurements, if any;
- numerical models and structural analysis, if any;
- diagnostic and safety assessment, if any;
- proposals for future interventions (if any);
- norms and regulations, where applicable;
- codes of practice;
- references to published and unpublished works, to experts, etc.

In this framework, items to be discussed are:
- possible structure of data bases;
- possibilities of national or international funding; operating costs, etc).

2.2.4 "Expert system" technologies to help in diagnosing structural troubles and in formulating investigation or intervention planning.

2.2.5 Formative activities, teaching, transmission of experiences.

2.2.6 Other ideas (initiatives at the national and international level; reduced-scale implementations to serve as a working example, funded by international or national cultural foundations or by large information-business corporations.....)

2.2.7 Multimedial techniques: possibilities for use in the documentation of historical monuments, where alphanumerical, graphical, photographical etc. documents are necessary and where archiving, cataloguing and access functions are presently not satisfactory.

2.3 (Conclusions) On the basis of recognized needs and opportunities (see above), as well as of past experience, one should be in condition to ascertain whether times are ripe for an intense, organized effort at bringing the full potentialities of information sciences to the help of monument preservation. In the alternative, one should discuss and identify what seminal initiatives could be taken to foster a rapid development.
It is highly probable that, in addition to institutional channels, technical and conservationist organizations should be contacted and sensitized to provide either partial funding or at least mass-media wide publicity and support.

3. (CONCLUDING REMARKS).

As a conclusion to the following considerations, it is suggested that possible guidelines and proposals be discussed among specialists (with knowledge, if possible, both of engineering and informatic aspects), with a view to formulate in due time

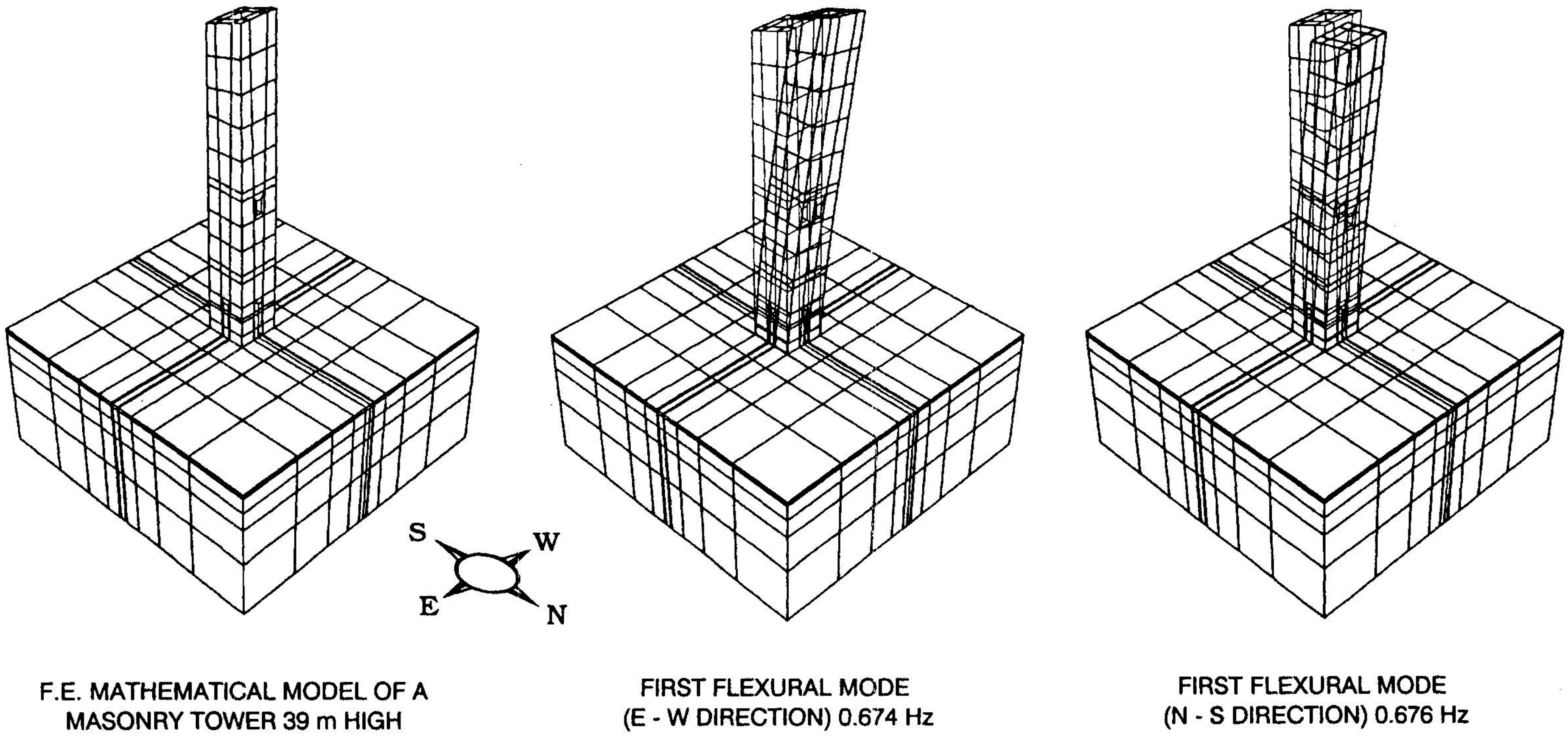


Fig. 2 - Examples of graphical rendering for a FE mathematical model of the tower of Fig. 1: Discretized geometry and first two vibration modal shapes.

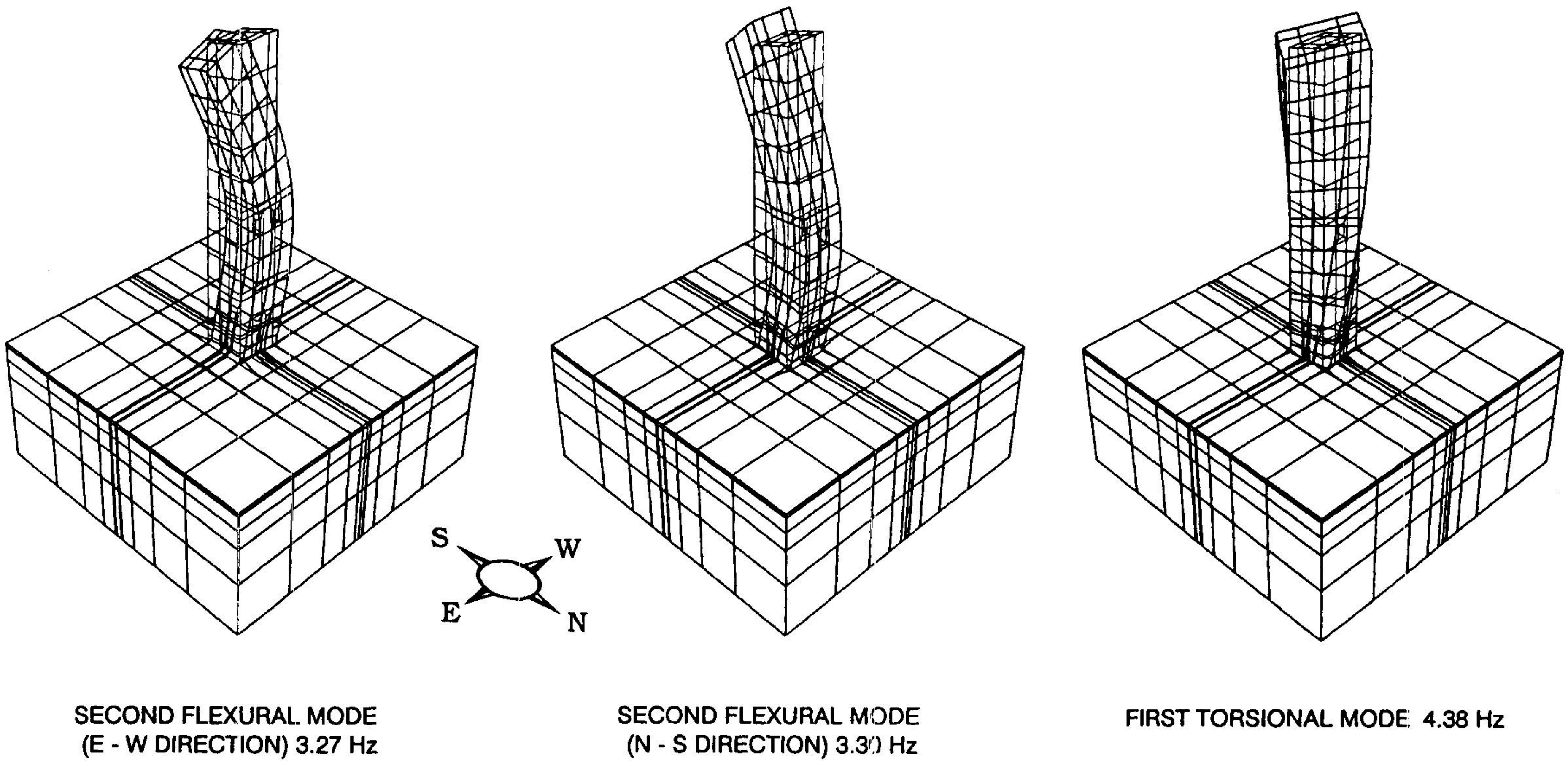


Fig. 3 - Examples of graphical rendering for a FE mathematical model of the tower of Fig. 1:
Third, fourth and fifth vibration modal shapes of the tower of Fig. 1.

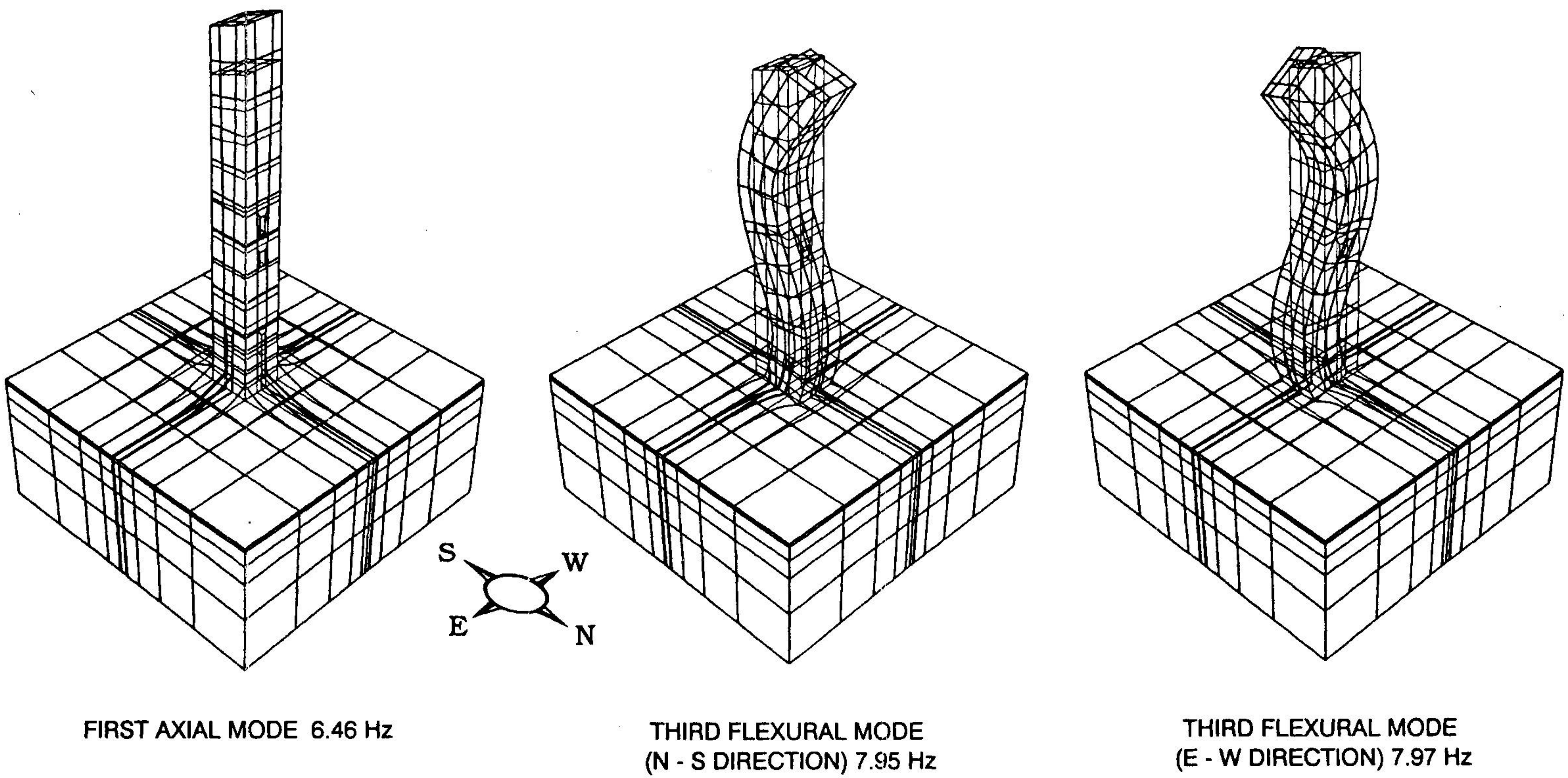


Fig. 4 - Examples of graphical rendering for a FE mathematical model of the tower of Fig. 1:
Sixth, seventh and eighth modal shapes of the tower of Fig. 1.

realistic proposals aimed at taking the first steps along the above-described road.
As a first suggestion, it could be envisioned to restrict initially the attention to a particular class of structures sufficiently homogeneous with each other, so as to reduce the size and difficulty of the task.
An example in point could be the cataloguing and documentation of "tall towers", of which there are numerous examples not only in Europe, but practically in all the countries of ancient civilisation.
Such a cataloguing and documentation could e.g. cover the following aspects (see also preceding point 2):

- history (age, interventions, important events: earthquakes etc);
- geometric definition of the structure;
- characterization of construction materials (type, degree of conservation, mechanical properties);
- characterization of foundations from a geotechnical or a geomechanical point of view (as above);
- dynamic characterization (eigenfrequencies, eigenshapes, damping factors);
- results of surveys and/or monitoring;
- structural problems;
- engineering studies so far;
- proposals for future interventions, etc. (including economic and environmental evaluations).

An effort of this kind could also help to detect important classes of common problems, to grade the structures according to their relative degree of safety, to establish priorities for interventions.
It could, last but not least, be a precious source for estimating residual life or deciding emergency measures in case of exceptional events.
The data base should of course be updated and maintained regularly so as to provide a realistic picture of the current situation, as well as to allow the users to detect time - trends of interest.
Such an endeavour could only be funded through public Authorities and on a national basis, but it would be wise to start at once with sufficiently co-ordinated criteria, so as to make possible fast, efficient exchange of information or even, at a later stage, the creation of a truly international Data Base.
If this first effort could be a successful one, it could then be extended to cover other classes of structures.
In this way the considerable difficulties that one can envisage in association with a broad program-such as, without doubt, is the one above described - could be subdivided in time and met with in a gradual manner.
It is deemed that a pragmatic approach, more or less along the lines already mentioned, could be the one with the greatest chances of success; it is also probable that the present time is the right one to start making proposals and, possibly, initiating demonstrative - if partial - projects in this field.