100-story John Hancock Center in Chicago: a case study of the design process

Autor(en): **Kahn, Fazlur R.**

Objekttyp: **Article**

Zeitschrift: **IABSE journal = Journal AIPC = IVBH Journal**

Band (Jahr): **6 (1982)**

Heft J-16: **100-story John Hancock Center in Chicago: a case study of the design process**

PDF erstellt am: **21.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-26292

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

100-Story John Hancock Center in Chicago – A Case Study of the Design Process

Le Centre John Hancock, 100 étages, à Chicago – Un cas pratique du processus de projet

Das John Hancock Center mit 100 Stockwerken in Chicago – Eine Fallstudie über den Entwurfsprozess

Fazlur R. KHAN
† March 27, 1982
Former Partner of
Skidmore, Owings & Merrill
Chicago, IL, USA

Born in Dacca, Bangladesh, Dr. Khan (1930-1982) received his Bachelor of Engineering degree from the University of Dacca. He studied at the University of Illinois, Champaign-Urbana, where he earned Master and Doctor of Structural Engineering degrees. In 1955, Dr. Khan joined the firm of Skidmore, Owings & Merrill and was made a general partner in charge of structural engineering in 1970.

SUMMARY

This paper is a continuation of the discussion about the interaction between architect and structural engineer which was initiated by two contributions in the last Journal J-15/82. The author, late Dr. Fazlur R. Khan, describes his positive experience with an early and close collaboration between architect and engineer during the design process and its fruitful influences on the architectural and structural characteristics of a high-rise building.

RÉSUMÉ

Cet article fait suite à la discussion sur la collaboration entre l'architecte et l'ingénieur civil, qui a été introduite par deux contributions dans le dernier Journal J-15/82. L'auteur, feu Dr. Fazlur R. Khan, décrit ses expériences positives d'une collaboration étroite et continue entre l'architecte et l'ingénieur dès le début du projet. Il souligne les influences positives de cette collaboration sur les caractéristiques architecturales et structurales d'un bâtiment de 100 étages.

ZUSAMMENFASSUNG

Dieser Beitrag ist als Fortsetzung der Diskussion über die Zusammenarbeit zwischen Architekt und Ingenieur gedacht, die in der letzten Ausgabe des Journals J-15/82 eingeleitet wurde. Der Verfasser, der verstorbene Dr. Fazlur R. Khan, schildert in diesem Artikel seine positiven Erfahrungen mit einer frühzeitigen und intensiven Zusammenarbeit zwischen Architekt und Ingenieur beim Entwurf eines 100stöckigen Hochhauses.

1. INTRODUCTION

The design process of any major building, in order to produce a successful result, must be multi-disciplinary in nature. The idea of the architect drawing up a nice sketch representing his vision of a building may have some possible validity for a minor structure such as a residential building or for a small commercial project, but would result in an utter architectural disaster for any major building requiring complex interaction between various planning, environmental, structural and functional disciplines. The 100 story John Hancock Center in Chicago (Figure 1) is certainly a good example of such a complex multi-use project. In looking back fifteen years one can now objectively discuss and elaborate on the various aspects and nuances of the design process of this major building which in fact could not be done as openly at the time of the actual designing of the building.

Fig. 1 100 story John Hancock Center in Chicago

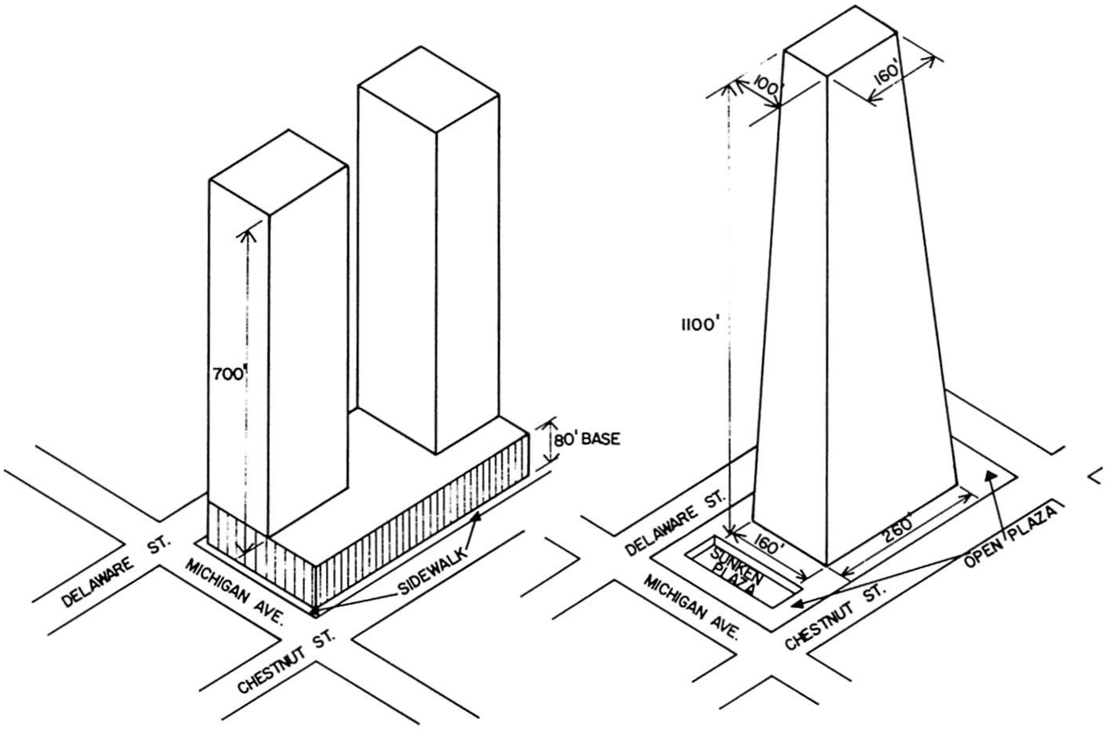

Fig. 2 Comparison of the traditional and the final architectural concept

The original program of the John Hancock Center was not a single tower, but a general requirement of a one million square foot office building and a one million square foot apartment building connected together with 800,000 square feet of commercial and parking structure. In the urban environment, this would produce diagramatically, a solution as shown in Figure 2 where the commercial and parking structure would be almost ten stories high and would create a wall character right at the property line of the site. The two towers, one for the office and the other for the apartment building, would be arranged in some optimal way to create the least disturbance in terms of visual effects. But the relatively small site of 145,000 square feet (13,485m2) could never resolve the need to have the office building and the apartment building sufficiently far apart. The rather mundane solution based on the program for the project would have also created a sense of congestion at the site and enhanced the canyon character so disliked in many of the urban centers of the industrial world. In search of a better urban solution, the author and his architectural partner, Bruce Graham, began to discuss possible alternate solutions which could offer opportunities to create a better urban environment at the site. Fortunately, at this time the structural concept studied and refined by the author came to great help. Two years back, Mr. Mikio Sasaki of Tokyo had come to work on a masters program in architecture at the IIT campus and was hoping to find a structural architectural solution of high efficiency and economy for a 60 story building. Mr. Myron Goldsmith, Professor of Architecture and the author were the two advisors helping Mr. Sasaki in developing the thesis project and had jointly proposed the possible use of exterior diagonals in order to make the entire building act as a tube construction. In the absence of sophisticated computer programs available at that time, the author and Mr. Sasaki tested structural models of the project for different loading conditions and generally came to the conclusion that the diagonals not only would act as traditional bracing, but, in fact, help in tying together all the perimeter columns as a part of the tube structure. It became a proven new structural concept waiting to be tested on a real building. John Hancock Center offered that opportunity.

In discussing with architect Bruce Graham, an exciting possibility became apparent. If the commercial, parking, office and apartment could be all put together in one building, then the large percentage of the site could be left open for ground level use by the public. The impact of the project at the ground level would be much less overpowering and in fact, would contribute to more human interaction so lacking in many of the recent projects. In spite of initial concern about large structural diagonal members crossing through windows in the office, commercial and apartment, the design team was finally convinced that the structural-architectural interaction could be taken to full advantage by creating an architectural expression of strength and elegance evoking the spirit of the rational Chicago School of Architecture.

2. BUILDING SHAPE

An efficient floor plan of a commercial or office building should be large, in the order of 25,000 square feet or more, whereas an efficient apartment building floor plan generally should be much smaller. More significantly, an office floor plan needs a lease-span of more than forty feet which means the width of the building can be more than 160 feet. An apartment floor plan on the other hand, cannot effectively use a large distance between the core and exterior wall (lease-span) simply because every apartment room is expected to have an exterior view and direct open exterior ventilation. Because of this reason, if there were no structural constraints, the volumetric form of the building would have been a wide office building that narrows down at the upper floors to a width acceptable for an apartment building. This means that while an office building could be wider than 150 feet at the base, an apartment building connot be planned with that width, but can have a realistic maximum width of perhaps not more than 125 feet. Schematically this would create an elevation showing stepping off where the apartment floors begin at the upper floors. But the structural system of the trussed tube structure requires a continuity of the four exterior walls throughout the height of the building (Figure 3). This structural requirement initiated a number of studies of the building slowly tapering upwards so that at the first apartment floor level the building width is reduced to an acceptable dimension for efficient apartment layout. Dozens of such shapes were studied with the help of a computer program which defined the exterior geometry in each case and computed the individual floor areas as well as the total floor area in the building to match the program requirements. The final shape selected had the base dimension of 160 feet by 260 feet tapering upwards to 100 feet by 160 feet at the top floor level. This double tapered truncated pyramid shape was a joint structural-architectural desicison satisfying both structural efficiency as well as architectural aesthetics of the form. The structural-architectural interaction in devising the form and shape of the building is another example of the close working relationship between the architect and engineer as a team rather than a preconceived design by an architect where the engineer has to simply solve the problem given to him.

In the beginning of the project the most important consideration for accepting this diagonally braced truss tube was its efficiency and economy. It had to meet a budget originally established to reflect the competitive traditional construction systems for the traditional two-tower solution. Fortunately on the basis of previous experience gained with Mike Sasaki's thesis, the author could realistically commit to a maximum of 30 pounds of structural steel per square foot for this 100 story building. Normally, a 30 pound per square foot budget would be set for a traditional frame building of only 30 to 40 stories. It is this attraction

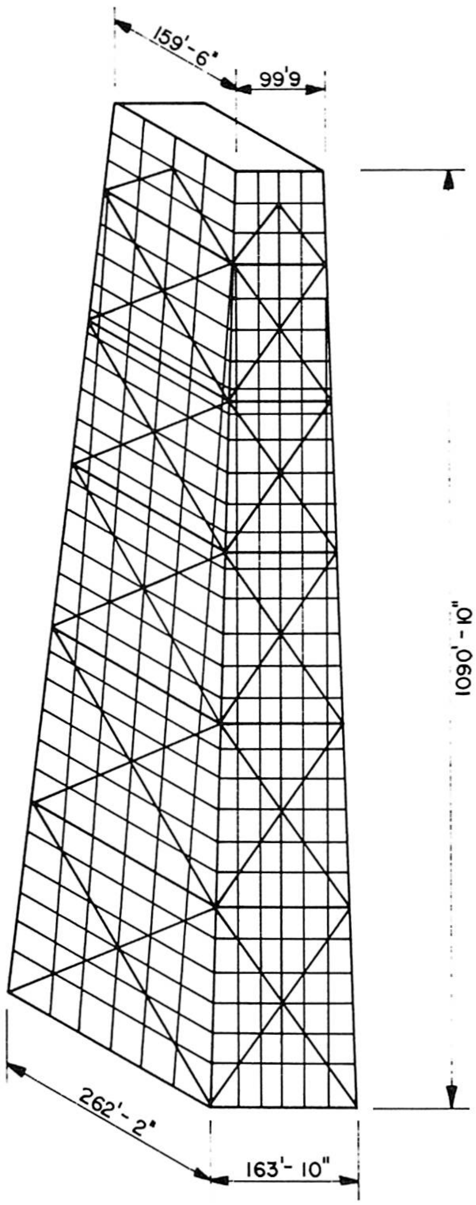

Fig. 3 Diagonally braced truss tube structure from bottom to top of building

of low quantity of steel and the assurance by the author that proper details can be developed to keep the unit price of steel the same as that of a traditional frame building, that helped to make the historic decision to go from a two-tower solution to a single tower of a 100 story building.

As the building was being developed and its structural architectural form was taking shape, the architectural team responding to the owner's concern wanted to take the diagonals on the exterior of the building only up to the 90th floor leaving the top few floors above the tube system (Figure 4). It was vehemently argued by the architectural team that the diagonals above that level would jeopardize the viewing and the interior openness to the outside which was presumed to be an imperative for studios and restaurants at those levels. First renderings of the building were developed without showing the top ten floors having any diagonals. Although one may argue that from a structural point of view one could have designed a building without the diagonals in the upper two floors, from a philosophic point of view and from a structural visual continuity of the system itself, it would be a tragedy to terminate the diagonals abruptly on the 90th

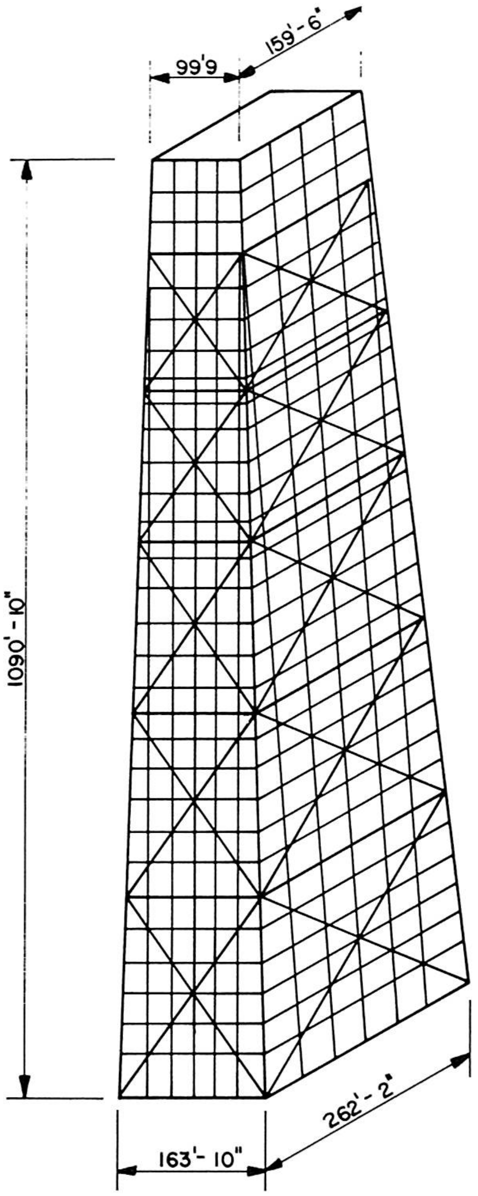

Fig. 4 Truss tube structure without diagonals above the 90th floor

floor. In various discussions this appeared to be a main point of difference between the architectural team and the author. However, at the end, the author made an impassioned argument that not having the diagonals on the upper ten floors would add a tremendous amount of additional steel to the building, the cost would skyrocket and it might, in fact, be too flexible causing motion discomfort on those floors. This argument finally won out and the diagonals in the upper ten floors were put back. The author, the structural engineer, and Bruce Graham, the architect, are now of the same opinion that the integrity of the structural-architectural expression of the building was indeed enhanced and recaptured by continuing the diagonal scheme all the way to the top of the building. Here is another very important example how the structural engineer can and should try to see to it that the structural-architectural concept once developed should be given its full visual expression without joepardizing any integral visual part of the concept. Although few can now recall this event, it is obvious that if structurally convincing arguments were not available at that time, it could have indeed resulted in a rather incomplete structural expression and would have lost a unique opportunity to create an architectural statement logical from the bottom all the way up to the 100th floor of this landmark building.

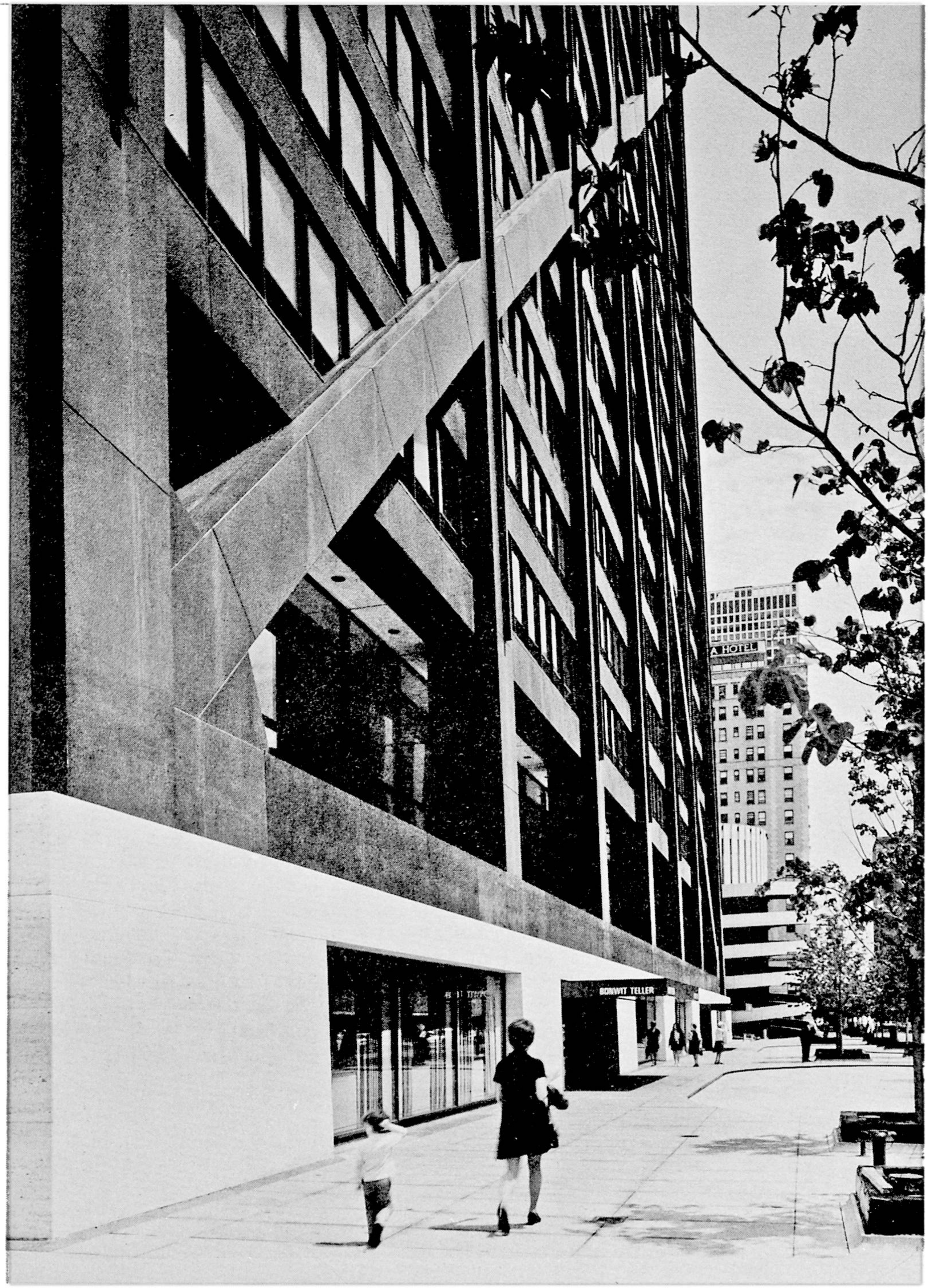

Fig. 5 Details of trusses, claddings and windows

3. STRUCTURAL DETAILS

A structural-architectural concept means that a structural engineering system has its possibilities and strengths in being expressed as an architectural statement, but it also means that the structural details must be developed in close cooperation with the architectural team so that the meaning of every joint and intersection be well represented and expressed in the exterior architecture form. In the John Hancock Center a great deal of effort was spent by the author working very closely with the architectural team to develop the architectural details of cladding and window walls so that the structure was expressed in as close in proportion to the real steel shapes and forms as possible. The major intersections of the diagonals, the horizontal ties and the vertical members were also developed in such a way that the structural form and its function were expresse accentuating the concept itself (Figure 5). One of the important examples is the cladding material itself. For a major structural system in steel such as the truss tube concept, it would be philosophically wrong to develop a cladding detail with stone or masonry. Not only would such cladding (enclosure) of the steel members distort their original proportions, but philosophically it would start giving the impression that the structure itself has a nonmetallic character. Here again considerable discussions were held and resulted finally in the cladding detail with anodyzed black aluminium which reflected the metallic character of the structure itself as well as retained closely the overall proportions of the structural members. In the author's opinion, the structural engineer cannot over look this visual interest in his structure. Working closely with the architectural team the structural engineer can indeed help developing visual proportions of the building that reflect more closely the real structure hidden behind the fireproofing and the cladding.

4. CONCLUSION

The process of design for major architectural projects often does not take advantage of team effort, of all disciplines working together to create the most relevant engineering architectural solution. A-priori architectural facades unrelated to natural and efficient structural systems are not only a wastage of natural resources but will also have difficulty in standing the test of time. The author, in this particular case, has attempted to highlight the structural-architectural team interaction which has resulted in a significant architectural statement based on reason and the laws of nature in such a way that the resulting aesthetics may have a transcendental value and quality far beyond arbitrary forms and expressions that reflect the fashion of the time. Through the case study, the opportunity and responsibility of the engineer to actively participate in the architectural evolution of a building is demonstrated. It is hoped that engineers will not abrogate this sense of responsibility in the face of architectural movement of today commonly referred to as post-modernism.