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Tall Buildings: A Look to the Future

Immeubles de grande hauteur: regard vers l'avenir

Hochhäuser: Blick in die Zukunft

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SUMMARY

In cities all over the world the single most dominant physical factor is the tall building, and in the last ten years their growth has been a vertical explosion. The paper projects the future developments: continued construction to cope with increasing urban population; greater attention to environmental impact and to social effects; more mixed use "megastructures"; structural designs that provide greater safety from natural hazards, greater reliance on probabilistic approach and computer-aided design.

RESUMÉ

Dans toutes les villes du monde, l'élément physique le plus dominant est l'immeuble de grande hauteur, dont l'accroissement au cours des dix dernières années a été une véritable explosion verticale. L'article considère l'avenir: poursuite de la construction pour tenir compte du développement de la population urbaine; attention plus soutenue pour les problèmes sociaux et d'environnement; meilleure utilisation des "mégastructures" à buts multiples; dimensionnement offrant une plus grande sécurité vis-à-vis des risques naturels; confiance accrue dans les méthodes de calcul probabilistiques et à l'aide de l'ordinateur.

ZUSAMMENFASSUNG

In den letzten zehn Jahren schiessen Hochhäuser explosionsartig aus dem Boden und werden so zum auffallendsten Merkmal aller Großstädte der Welt. Der Artikel schätzt die zukünftige Entwicklung ab: Bau von weiteren Hochhäusern, um mit der Bevölkerungsentwicklung Schritt zu halten; sorgfältigere Beachtung der Einflüsse auf die Umwelt und der sozialen Probleme; Förderung vielseitig genutzter Megastrukturen; grössere Sicherheit gegenüber Umwelteinflüssen durch wachsendes Vertrauen in Wahrscheinlichkeitsmethoden und computergestützte Berechnung und Bemessung.

Cities are changing all over the world, and more dramatically in recent years. In the industrial countries some cities are actually decreasing in population - some to the extent that they are in trouble. But these are the exception. In most industrial countries most big cities are still growing.

In nearly every developing country the large cities are getting even larger. It is here that the growth trends are the most striking. Cities of 5-million population now are projected to 20 million by the end of the century.

The single most dominant physical factor in all of these cities, both for industrial and for developing countries is the skyscraper. Although less than 100 years old, it has transformed the skyline. Whereas in the past buildings of great height were limited to a few major cities, within the past 10 to 15 years there has been an explosion upwards. As shown in an ongoing survey carried out under the auspices of the Council on Tall Buildings and Urban Habitat, in city after city the majority of their tallest buildings were built after 1960 (Driscoll et al., 1976). Even small towns have tall buildings; occasionally one even finds them in suburbs.

Preceding the explosion upwards was the explosion outwards as the automobile lent mobility to the worker. Suburban growth was a world-wide phenomenon that is even now continuing in most parts of the world. Highways were improved. Everyone could own a car and (theoretically) live wherever he pleased.

But the erosion and absorption of agricultural land and environmental and energy concerns have recently shifted attention back to the urban core. And since most of these cities are already congested, the present situation brings into sharp focus the need to consider the design of the city. And the tall building, as noted, is one of the most crucial ingredients in this design process. Over the past five to ten years there has developed a more general awareness of this fact and a greater concern for the environmental impact of tall buildings. The Council on Tall Buildings and Urban Habitat (formerly the Joint Committee on Tall Buildings) was formed, in fact, to stimulate such awareness and to document those factors that would lead to greater economy in construction, recognizing the crucial role that the tall building plays as a part of the urban scene (Beedle, 1976).

It is the objective of these remarks to look to the future of tall buildings. What's up ahead? What can we expect? What developments are we going to see in their role, their function, their design?

First, we should discuss some conditions that now exist or will exist in the future -- the constraints that will eventually guide what we do. It will also be well to look at ourselves as designers -- and to our motivation. In this latter connection we could ask ourselves what kind of a building would we design if the matter were completely in our own hands.

- In our worst moments, if the office is busy, we would perhaps choose to repeat something we had designed before -- where we could just get out the old schemes and modify them.
- In the moments when we are most human we might aspire to the world's tallest.
- But in our better moments our goal would be to design a building useful to mankind -- one that fills a need.

Because it is the "need" that is getting the attention now, as well as the quality of that need. We live in an age of "awareness". We are more and more aware of the effect of our creations on the environment -- and hence on people. We are aware of growing shortages that dictate a more careful use of strategic resources. Money is scarce. Past values are being questioned.

Let's look at the world, then, and see what the need will be.

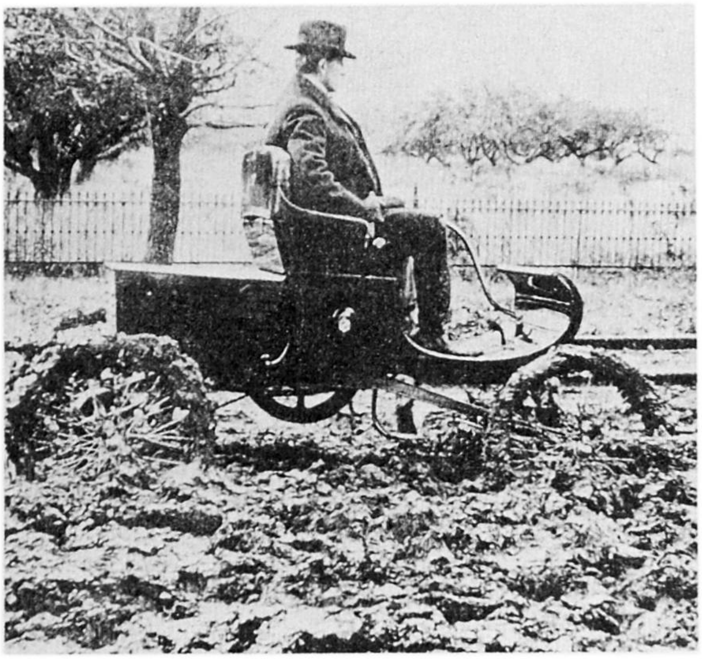


Fig. 1 Change: An American traveller less than a century ago.

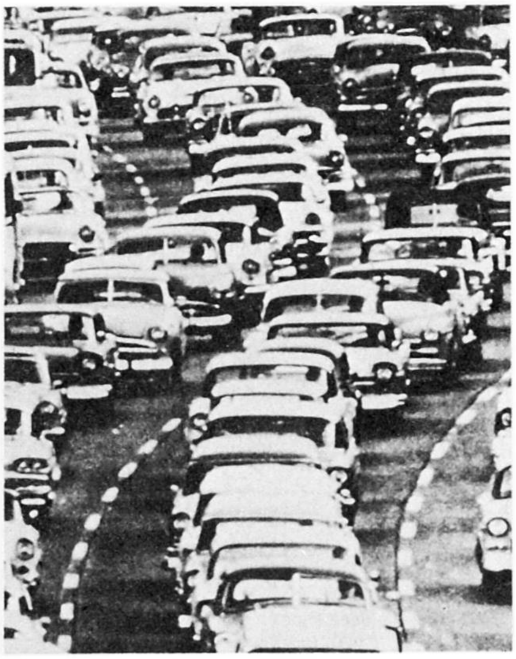


Fig. 2 Traffic congestion: Now the traveller is stopped not by the road but by other travellers.

<u>Conditions (28)*</u> In making this assessment we have to start from the assumption that there will be no cataclysmic failure of world society. This may sound like an unnecessary proviso, but a comparison of the way of life 75 years ago with the present world situation emphasizes how rapidly things are changing.

*For the sake of the reader who may wish to explore more deeply into a specific topic, the number in parenthesis that follows the headings refer to the corresponding committee of the Tall Building Council, previously referred to, that is currently (1977) completing a monograph in this field.

The automobile, radio, television, computers, space vehicles -- these are things that have completely changed our lives.

Further, we will be going through a potentially dangerous time of transition as new governments sort out their modus operandi. Rhodesia, South Africa, the Middle East, post-Mao China, and even the concerns in the United States -- the near-bankruptcy of New York City in the midst of the celebration of a Bicentennial year pointing to a crucial need for attention to urban problems. In many parts of the world meaningful long-term construction programs will be difficult to carry out.

The over-population problem can still be listed at the top of the world's most serious. In 1930 our planet had reached a reportedly "comfortable" population at 2-billion. It has now doubled and will nearly double again by the year 2000. There will be increased efforts in the direction of population control,

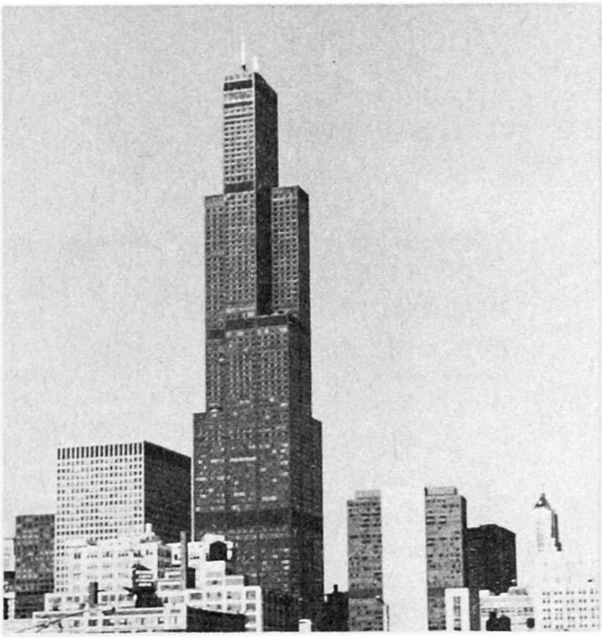


Fig. 3 Sears Tower in Chicago currently (1977) tallest in the world. 110-story office building.

Fig. 4 Apartment construction in Bombay, India, is part of the explosion upwards. This form of construction will concentrate in the 10- to 20-story range.

that in India being one illustration. With the gradual industrialization of developing countries, there will be a consequent decrease in the population growth rate even in these regions (Scientific American, 1974).

More and more people the world over will realize that the control of population will also cut down on the demands by the yet unborn for services, food, structure, and life-style upon which so much of our way of life depends. The population growth rate will decrease. It must.

<u>More Tall Buildings (28)</u> There will be a significant increase in the construction of tall buildings in the near future. The pressure is two-fold: First is the rapidly growing population and the move towards industrialization by developing countries (and from industrial to service-oriented functions). Second is the cost of horizontal growth, the explosion outward. Land is removed

from food production and the cost of energy and urban services is not in balance (Moser-Khalili et al., 1977).

Don't watch for a cessation in the race for the sky. "To build the tallest" is a human tendency that reflects itself in attitudes of organizations, in communities, in cities, and in nations. The difference is that more and more this prestige motivation will be appropriately coupled with urban goals.

All the same, the emphasis in construction will be on the lower side of the height scale: the preponderance of tall buildings will be in the 10 to 20 story range. Those above 50 and 60 stories will continue to be the exceptional.

Role of the High-Rise (28) There will be better recognition of the role of the high rise in urban concentrations. A few will be built where they don't belong. Some will be stopped that should have been built. But the large majority of those that are built will serve their intended function.

Means will be developed so that decision makers will know in advance the proper directions in which to go. We will find better decision-making techniques for ascertaining in advance the suitability of a particular high-rise building, a tall building complex, or a tall building policy (Moser-Khalili et al., 1977).

More and more we will realize that the way we conduct business controls commercial office buildings. Agglomeration is the "raison d'etre" of tall office buildings. More tangible evidence will be forced upon us that unrestricted continued growth of suburbs isn't worth the cost -- the cost in agricultural land removed from food production and cost in energy and urban services to maintain them as remote from the urban center.

In the United States we will see office buildings that have had space going begging over the past few years begin to fill up again as a result of disillusionment with the flight to the suburbs (Laub, 1976).

Mixed Use (28) Probably the most significant trend of the future will be mixed use (or multiple use) of high-rise buildings for a variety of functions. Recent examples are dramatic (Hancock Center in Chicago; Omni in Atlanta; People's Park in Singapore; Water Tower Place in Chicago) but the principle is no different from that which exists in the old European towns: shops on the street level, residences above, and sometimes offices in between.

We got away from that in the past with the construction of separate buildings for different functions. In future we will see a return to it with the construction of more "vertical villages".

Megastructures (30) The structures to go with multiple or mixed use, called "megastructures", will provide new creative challenges to the structural engineer. Such structures frequently will be unique in form. Some will be successful, some not; the methodology is still developing. They will contain provision for nearly every function that a building can provide, and all under one roof: housing, office, hotel, shops, restaurants, supermarket, industry, health care, education, recreation, and entertainment. One can imagine the design complexity -- and the options. As Khan describes it (1976):

> "We've got to have open options of going high-rise or low-rise, so that certain parts of the megastructure may be only two stories, whereas another section will be five or six stories high. Again, the theme center or nucleus could soar up 100 floors. But mind you, it would not be a series of monotonous slab-sided structures block after block or side by side."

Perhaps the most visionary of the megastructures are Soleri's "Arcologies", described by Lindgren (1976b) as "the best known, most publicized, and least built of radical new city concepts." We're not going to forecast that one of these will be built very soon. Whether on land or floating in the ocean, all the sketches suggest approximately a one-mile vertical dimension (up or down).* There is even a 10-km-long "space arcology" for 2 million people. (At least the designs won't have to contend with earth's gravity!) One guesses that the practicality of such projects have not developed to the point that even a preliminary structural design has been made.

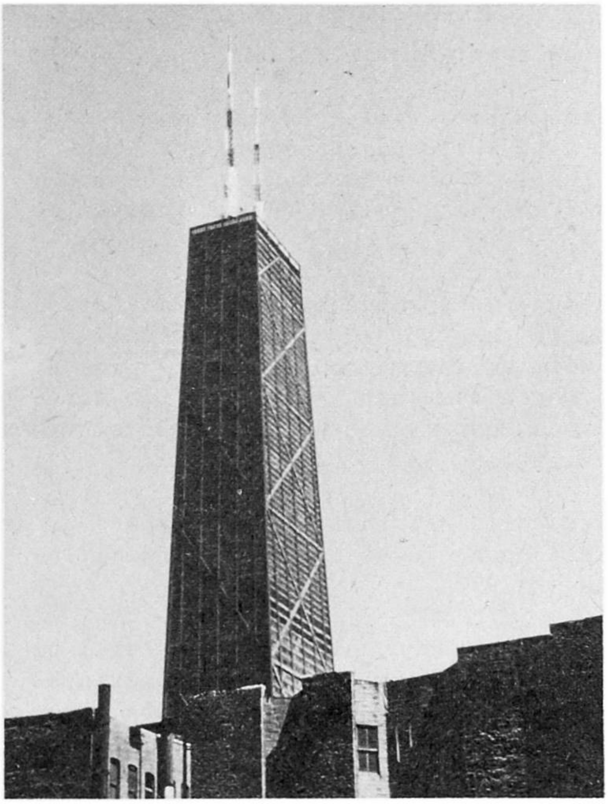


Fig. 5 Hancock Center, Chicago, is an example of a mixed use (multi-function) building. A "megastructure", it envelops, among other things, offices, apartments, parking space, shops, restaurants and recreational areas. A 100-story vertical village, 351m in height.

Fig. 6 Rockefeller Center in New York is the world's largest privately owned business and entertainment center. The 70-story RCA building towers above 20 other buildings that range from 6 to 48 stories in height.

Megastructures in the form of complete cities of 250,000 population are described by Dantzij and Saaty (1973). They may be built sooner than Soleri's arcology, but there is still a long way to go, according to SPECTRUM (1976, p. 48). The appeal is to energy savings (it could be as much as 25% of the total energy consumption in the U.S.). The difficulties are claustrophobia and the

*Novanoah II (the floating version) is illustrated in SPECTRUM (1976): a population of 2.4 million ... covers an area of 2790 hectares ... living areas above water ... commercial space below ... deeper still, industrial areas where submarines are docked ... resources extracted ... harvested.

control of people's lives. Who is to say that the people will want to live and work and play all in the same place.

Cities Within Cities (31) The next steps in the practical sense are cities within cities. They are already developing, one of the most dramatic being the Ikebukuru New Business Center in Tokyo. It is an example of the "decentralized concentration" as defined by the Swiss (Basler, 1973). Ikebukuru features an office tower 60 stories and 234 m. in height (in 1976, the world's tallest outside North America and Europe). Included are the following: offices, department store, specialty stores, restaurants, amusement facilities, apartments, education and cultural facilities, parking, bus terminal, power supply, a hotel.

Recycling of Buildings (3, 4) We should see the fruition of ideas about the recycling of buildings (Friedman, 1975). The high percentage of overbuilt office space (estimated in mid 1976 as 30 to 40% in New York city) and inevitable in a severe recession means that: 1) Alternative uses should be explored and 2) Design should be carried out in such a way as to offer maximum flexibility of use.

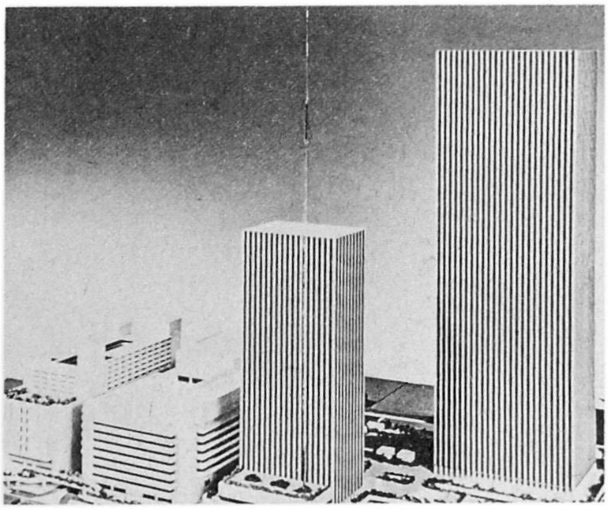


Fig. 7 Tokyo's Ikebukuru New Business Center currently under construction (1976) is one of the world's most complete "city within a city". It will be a self-contained community.

Fig. 8 New York City skyline with Statue of Liberty in foreground. Whether consciously or not, addition of high-rise buildings changes the design of a city -- as seen from outside the city gates. World Trade Center's twin towers can be seen to the left.

Design of the City and its Skyline (31) We will see more of what San Francisco did in the early 1970's in the development of an urban design plan that takes into account buildings of great height and bulk (Kavanagh, 1973). This conscious design of the city is of more than casual concern. As Eric Hoffer said,

> "Not a single human achievement was conceived or realized in the bracing atmosphere of steppes, forests or mountain tops. Everything was conceived and realized in the crowded, stinking little cities of Jerusalem, Athens, Florence, Shakespeare's London, Rembrandt's Amsterdam. The villages, the suburbs, are for the dropouts ... we will decay, we will decline if we can't make our cities viable. That's where America's destiny will be decided -- in the cities."

The design of the city demands a structured answer to the question "what is a city?" Our largest American cities do seem to be developing into the "endangered resource" predicted by Jane Jacobs (1961). Since our practice as professionals depends more than anything else on the viability of cities, it may not be amiss to remind ourselves of their importance as centers of employment, trade, and culture. Places where we can lose our identify if we like or where we can look for a new one -- or at least refresh the old one. "Cities have definite and recognizable characteristics that people seek out to enrich their lives, and by going there enrich the 'placeness' of these cities" (Lindgren, 1976a). Architect/Developer John Portman has said, "only downtown can Americans find the activities that make life significant" (TIME, 1976).

It is of interest and significant to the changing conditions of cities in the U.S. that at least three major journals selected the American city as the feature of their special Bicentennial issue (CIVIL ENGINEERING, SPECTRUM, DESIGN AND ENVIRONMENT). And more than passing attention was given to tall buildings in these journals. Even TIME, often critical of the high-rise, came out on the positive side in its "Birthday Issue", stating (1976),

> "It has often been said that a nation's buildings express its aspirations and its character. If so, the downtown structures of the 70's surely indicate a new attitude toward cities. By declaring a greater concern for amenity and beauty, the buildings point the way toward a renewed sense of community, of civic pride. The proud towers raise high a message of energy and innovation as the U.S. enters its third century."

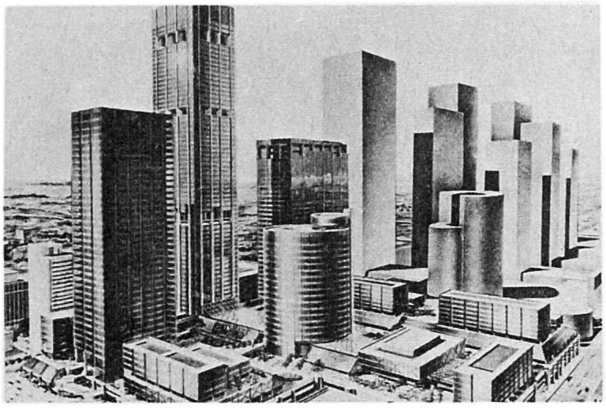
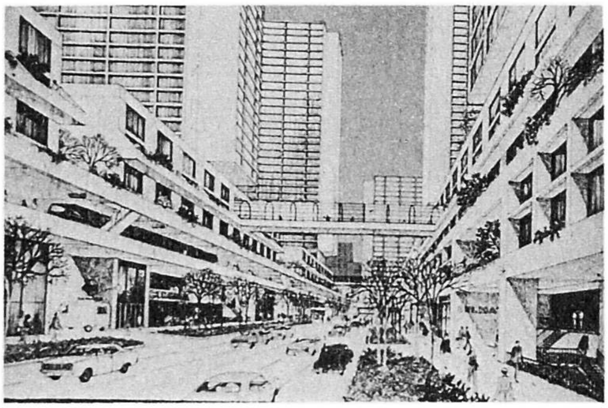


Fig. 9 Houston Center is being built in a center-city area that had fallen into decay.

Fig. 10 Chicago's "Project 21" will feature construction of vitally needed facilities, thus "recycling" that part of downtown that was formerly devoted to railway facilities.



<u>Recycling of the City (31)</u> With few exceptions, most cities will go through a recycling in order to correct the unintended and unanticipated errors that were made when the zoning and other control provisions did not anticipate the consequences of uncontrolled growth.

This will be a more or less continuing process in those parts of the world where "newness" is the way. Large cities in developing countries will, in particular, go through this process, because they are extensions of village-hut oriented concentrations.

On the other hand in older cities with a long history behind them, this process will be much slower and will concentrate on the preservation of older structures and the opening up of vistas and access to them so that these fine buildings can be appreciated. Burns (1972) describes it as "converting" cities to answer present-day needs with the older resources.

In any case, attempts at new modes of human settlement are as old as man. It is in his nature to create and to recreate out of that which he destroys. Only nomads abandon their settlements, and what they leave -- is nothing.

The tragedy of war-damaged Lebanon, like that of Warsaw, Dresden, and Rotterdam, provides an opportunity for urban renewal that most certainly combines aspects of repair, of replacement, but also of redesign. What happens depends on the will of the people and the emergence of both political and professional leadership.

New Towns (31) Will our talents be put to use in the design of new towns? Yes, but not in the pattern of the recent past. Many such developments have only succeeded in providing their own employment and, as Lindgren points out (1976a) have attracted middle and high-income groups. That is not where the problem lies.

The new towns of the future will have some raison d'etre -- a transportation interface or some other activity compatible with the function of a city. And they will be designed, not according to the older "bedroom community" idea, but more for a totality of urban living -- such as those in Singapore and Hong Kong. Such a need was cited by His Excellency the Governor of Hong Kong on the occasion of His announcement of plans for Hong Kong's new towns of Sha Tin, Tsuen Wan, and Tuen Mun (Public Works Department, 1975):

> "For such a program to succeed and to be acceptable to the potential inhabitants, three things seem to me essential. First, good communications with the old urban areas. Secondly, the housing in the new towns must be accompanied by a full ration of what is essential to modern life: medical, and secondary as well as primary educational facilities, parks and playgrounds, police stations, markets, fire and ambulance stations, community centers and much else. Thirdly, there must be work, and so sites for private commercial and residential development. These towns in fact must be built as a whole."

Colonies in Space (28) Whether or not they come into being in the next decades, colonies in space will certainly be written about (Asimov, 1976, Herren & Johnston, 1975). They are technologically feasible and could be built within a 20 to 25-year period. Estimates of the size of a first colony are in the range of 10,000 to 20,000 inhabitants -- about what could be accommodated in a single megastructure. A mature colony would have a population of 200,000.

The motivation for building space colonies is the question. And it must be for more than an outlet for the exploding population -- currently at the rate of 200,000 per day.

Transportation (32) There will be a recognition of the potential of transportation centers as a functionary justification for tall buildings. It is no accident that Hong Kong's tallest building, for example, is closest to the ferry terminal. Or that the 40-story World Trade Center and 34-story Excelsior Hotel are convenient to the trans-bay tube. The development of high-rises at transportation interfaces is a tendency that should be encouraged by planning. Just as bays and river ports were the focus for many older cities, so also we will see the highway interchanges now in rural areas gradually develop as foci for new towns.

The advance planning that has gone into the development of Hong Kong's mass transit system is signal, especially (1) the creation of new communities and commercial activity virtually atop planned stations and (2) the direct connection between as many buildings as possible and the stations themselves.

Telecommuting (32) There will be more experimentation with telecommuting (substitution of telecommunication for transportation), varying from decentralization of service-oriented industry to the "cottage industry" approach. The question is, will telecommunications replace the need for actual physical transportation to urban centers and tall buildings? It will be worth examining, since commuting by automobile in the USA accounts for more than 40% of all urban transportation mileage and 4% of total energy consumption. Transportation uses 25% of its energy.

Nilles (1976) describes a Los Angeles study in which decentralization to nodes of existing transportation networks would reduce commuting by 50%, save employees $1 million annually in transportation expense and, in effect, release two weeks of vacation time per employee for one firm. He then cites the ultimate:

Fig. 12 View from Hong Kong skyscrapers of transbay tube terminus around which they have sprung.

Fig. 11 Tao Payoh, the "new town" in Singapore, is designed for near-totality of human living.

> "Individuals could live essentially in areas of their own choice and work where they wish. An individual working in Los Angeles, for example, could eventually work almost as easily for a firm in London as for one in Los Angeles without going far from home."

In an actual experiment by an insurance company productivity went up by 15%, job turnover went down by 60%, and most employees at the "remote" site did not have to drive their cars.

Involvement in Planning (38) We will see more people involved in the planning process. This will include not only those who do the planning but those in the user category. Citizen participation, strong in recent past, will continue to increase in the future. The design team will come to welcome it because the user will add, by practical experience, his own ideas and insights (Burns, 1972). There will be new emphasis on the local neighborhood. Its people will more and more decide (or at least influence) what is to be built; so they will be listened to, and informed, more than ever in the past (Ruchelman et al., 1977). The actual input of the citizen (the user) may be direct but most often it will be through the social scientist who, as Reizenstein says (1975), can better articulate user norms and values.

Government decision makers will seek out more professional opinion. And we will see more social scientists as members of the design team. It will help bridge the gap between the designers' experience and the more intimate involvement of the actual user (Reizenstein, 1975).

Energy-Sensitive Design (39, 40) In some parts of the world it has been routine to provide designs that are sensitive to environmental effects and which take advantage of natural phenomena (sun, ventilation) (Aynsley et al., 1977). There will be more and more attention to this function in the future. In fact Lindgren suggests (1976) that "energy awareness" may be the single strongest factor to influence the shape of the "City of the Future".

There will be more attention to interference effects and to the environment. Studies by the San Francisco Planning Commission are a case in point (SPUR, 1975).

Apartment Living (37) We are going to find out a lot more about high-rise apartment living. Mostly this will come about as a result of more sophisticated surveys of residents (rather than the opinions of people who've never lived in high-rise apartments). The results will show more satisfaction than one would guess from the popular press.

As an example, a 1976 survey was made of apartment residents in Cologne and in Rome. Using a survey procedure designed by Lehigh University social scientists, the actual details were carried out by nationals in each country

Fig. 14 In the future more people will be involved in the design process. Currently in many projects the "designer" is a team (architect, planner, engineer, landscape specialist, even social scientist). They must interact with other professionals in the "decision making" categories.

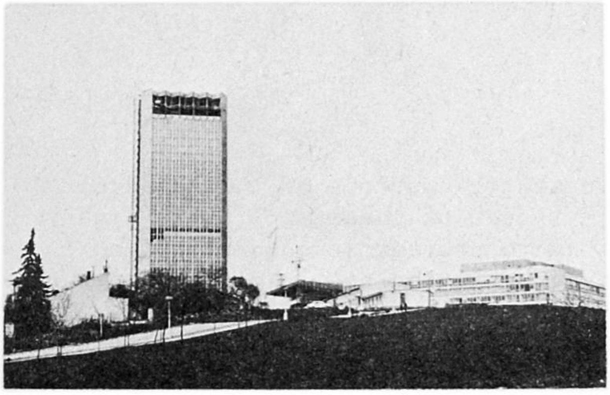
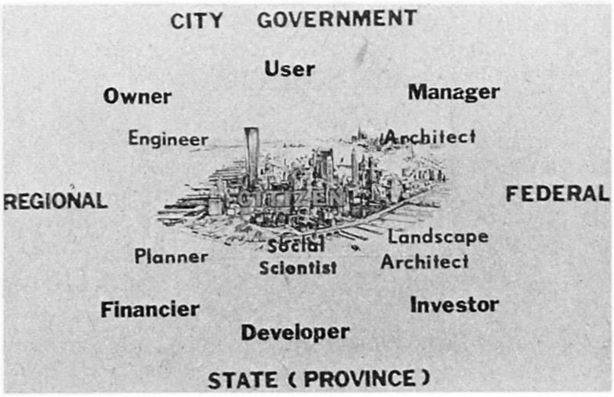


Fig. 13 "Telecommuting" (telecommunication instead of travel) may help ease the transportation problems, but it is notable how many telecommunication facilities are housed in high-rise structures. (Television building in Bratislava, Czechoslovakia)



(Williamson, 1976). The result: In both countries the majority were "satisfied" or "very satisfied". The "not satisfied" was 7% in the German sample and 22% in the Italian.

Advantages cited for living in high-rise apartments were the view, the architecture, and amenities. Principal disadvantages: the elevators, impersonality, and noise. Interestingly, the people living in high-rise apartments were reported to be more involved with the community and seemed to have deeper political concerns.

This doesn't mean that the problems are all solved. One can't be complacent, but must deal in the best way possible with the "principal disadvantages."

Much more attention will be paid in the future to factors that have been found to be essential in the housing schemes that have been successful, especially in Singapore and Hong Kong: Resident participation in management, maintenance, emergency service (particularly of elevators), the opportunity to choose, provision of amenities (Haddon, 1975; Housing and Development Board, 1975).

Structural Systems (3) It is doubtful that we will see a sudden doubling in height, say to 200 stories (Robertson, 1972). Structural systems take some time to evolve. What we will see is extension of present systems to, perhaps 150 stories (Khan, 1972). And we may well see connecting structures, now used as bridges, that will be structurally designed to enhance the lateral response characteristics of the thus-connected tall buildings. There will be more structural innovations worked out cooperatively between architect and engineer.

Fig. 15 Mei Foo Housing Estates features plazas adjacent to every apartment. When completed the project will have approximately 100 twenty-story buildings, containing 13,000 apartments in addition to shops, market stalls, classrooms, restaurants, and community rooms.

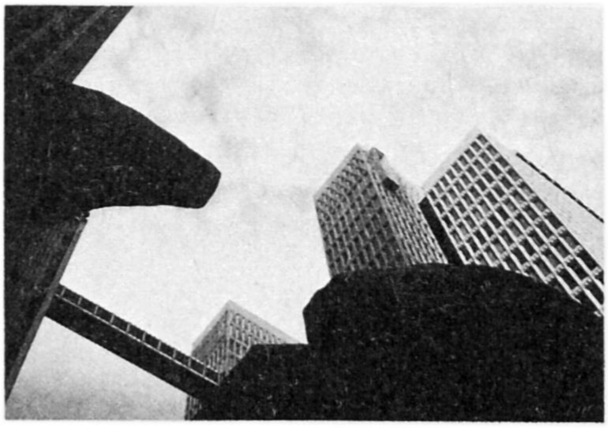


Fig. 16 Bridges currently in use simply for horizontal transportation between tall buildings may one day be designed to provide lateral stiffness. (Peachtree Center, Atlanta)

Earthquakes (6) Although it is sad to state, hundreds of thousands of people will die in earthquakes. However, very few of these will be in high-rises. Although design methods are available to prevent structural collapse (Muto and Hart, 1977), failures will continue until the poorly-designed structures are shaken down or taken down -- the capital investment for the latter simply being too big for other than cosmetic effect.

Unfortunately, new low-rise structures, not designed for earthquake resistance, will continue to be built in some countries until ordinances prevent it. But that will take time. The periodicity of a severe earthquake in the same region is such that several generations can pass without a recurrence of severe damage. And so the incentive is lost.

We will see steady improvement in the ability to accurately predict strong earthquakes.

Wind (7) It is not expected that any high-rise buildings will be blown down. Tall buildings continue to be the safest kind of building to occupy in this regard (other than a specially designed shelter) (Davenport et al., 1977).

More needs to be learned about full-scale response of high-rise buildings under extreme wind. (By some curious but not unwelcome perversity ever since the completion of the 10-story test building at Cape D'Aguilor, Hong Kong, all of the extreme winds have by-passed the island.)

The major danger continues to be flying objects. Improved cladding techniques can be expected.

Fire (8A) Fewer and fewer people will die in high-rise fires. Even now, in countries with modern fire protection codes, the number is small (in the USA less than 0.1% of all fire deaths). In countries without such codes there will be better application of known technology and thus eliminate such catastrophies as occurred in the Andreas building in Sao Paulo (Uribe, 1973). In steel buildings there will be a better definition of those cases where exposed steel can be permitted.

In climates in which it is feasible there will be more application of the "safe refuge area" idea, believed to be first started in Hong Kong. An example

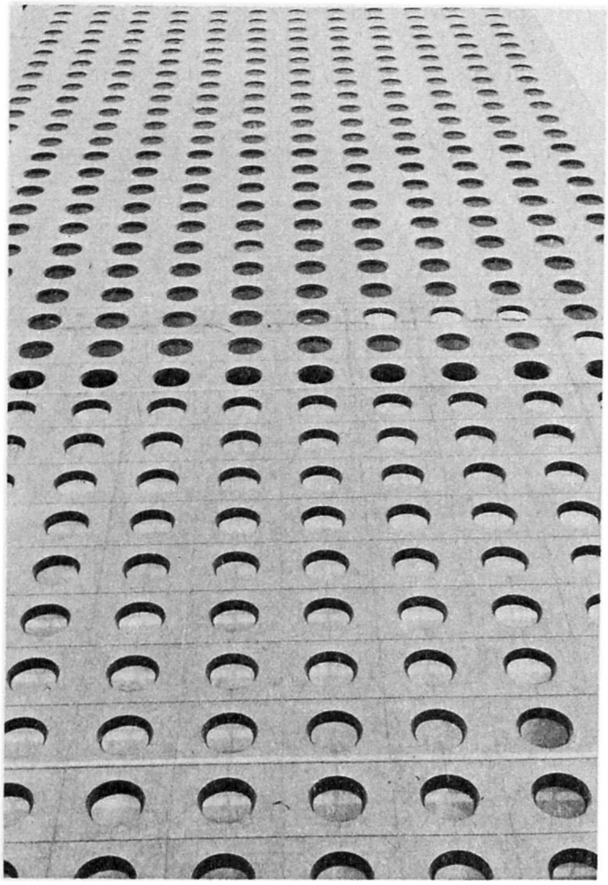


Fig. 17 Connaught Center (Hong Kong). Dark circles are windowless openings at the "safe-refuge area" floor.

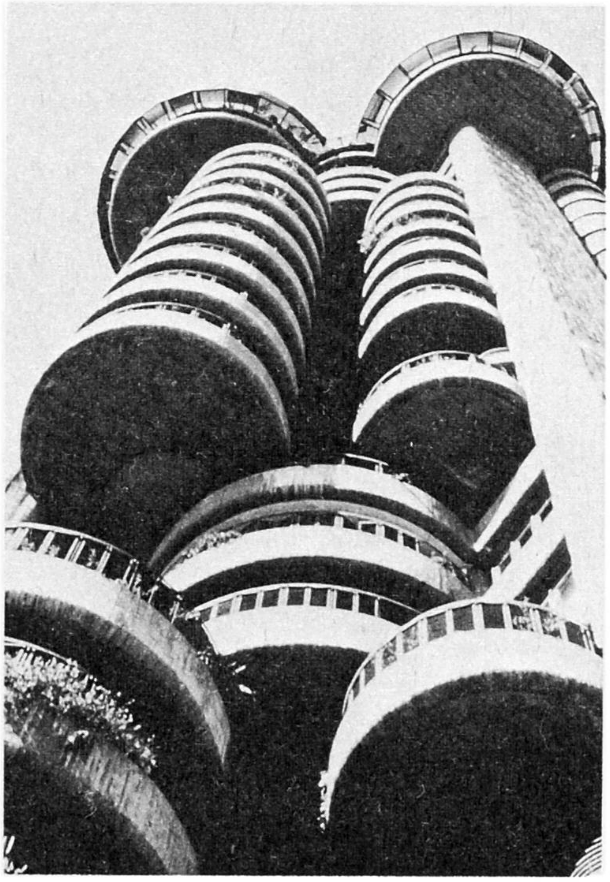


Fig. 18 Torres Blanca (Madrid) features non-traditional use of concrete.

is Connaught Center in which the one-meter-diameter round windows at the 17th floor appear darker than at other levels. The reason is that they are completely open, and the level is an area to which people can go to escape fire and smoke -- in a building obviously too tall for stairway evacuation to the street level.

Structural Design (SB, CB) In steel buildings the problem is stiffness. What we will see in the future is the development of more rational drift limitations, a consideration of the influence of cladding on a quantitative basis, and stiffness criteria based on comfort criteria (Higgins et al., 1977).

In concrete buildings the problem is weight. Thus the further development and use of high-strength, light-weight concrete is to be expected (Reese et al., 1977).

But the most remarkable developments will be in the realm of mixed construction -- and by this we mean composite steel-concrete members and the use of mixed systems. In the latter, for example, steel frames and concrete walls would be designed to act together. It is a scheme that apparently had its beginnings in Spain and has been rapidly advanced by the Japanese.

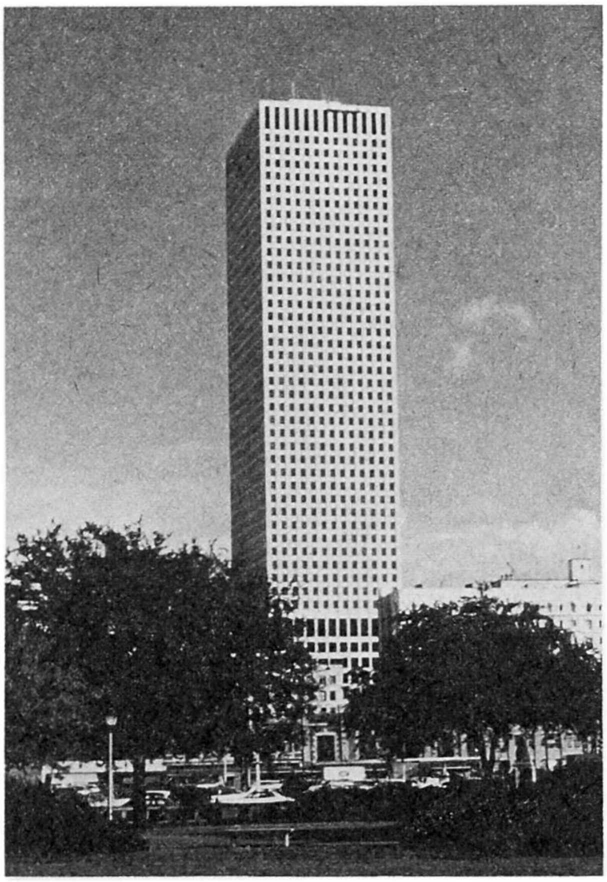


Fig. 19 One Shell Square (New Orleans) features mixed construction.

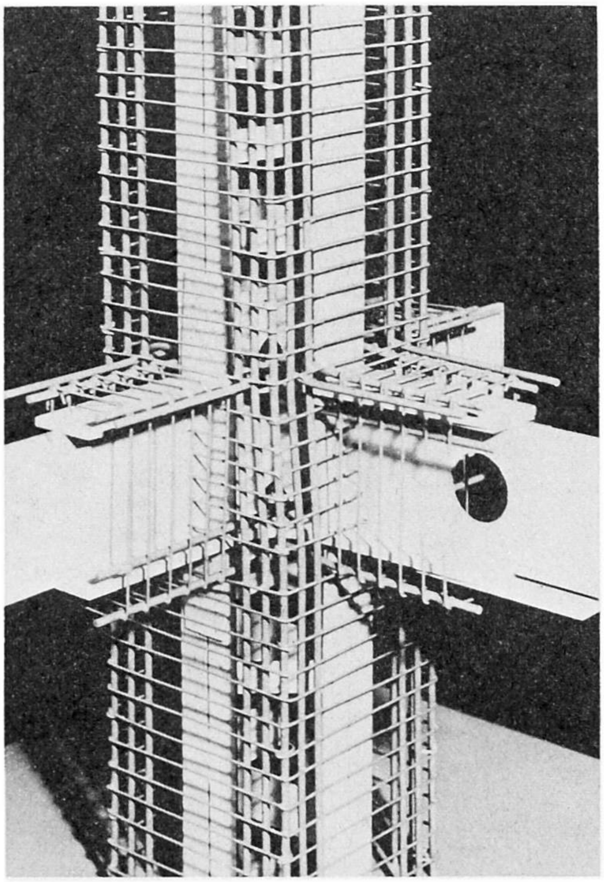


Fig. 20 Connection in building for mixed construction (model).

In the Tall Building Monograph a completely new chapter is devoted to mixed construction, with input from 10 countries in which active developments have taken place (Naka et al., 1977). The merit of the technique is economy. In a 36-story building in Chicago (Gateway 3), steel was saved, erection time decreased, and an estimated 15% in total cost was saved by taking advantage of the best characteristics of steel and of concrete.

Probability in Design (10) There will be more reliance placed upon maximum load as the design criterion (Plastic Design, Ultimate Strength Design, Load and Resistance Factor Design, Limit States Design). We will see all such techniques combined under structural design, probabilistically based. In the future it will be the fundamental design approach (Batanero et al., 1977; Levi et al., 1977).

There will be a shift away from deterministic safety factors; instead, load and resistance factors based on probability will be used. It is a technique fully provided for in the specifications of some countries. In others it is not incorporated at all. In the USA, for example, it is included in the ACI code (1971), but has not yet been included in steel specifications, although currently (1977) recommendations are going forward to the AISC Specification Advisory Committee (Galambos, 1976).

The advantages of the new approach are (1) savings of material in certain loading conditions, ... and (2) the provision of more uniform safety.

Design Approach (35) Even though the so-called "traditional" approaches to design will continue to be used, there will be a continuation of the radical changes in the process that we have seen in the recent past. In the long term we will see more and more design carried out with the aid of the computer. Computer-oriented information systems and data bases, now available to the medical profession in the USA also will be available to the building design team (Yuceoglu and Lu, 1976). Instead of turning to Manuals, references and specifications, the design team will look more frequently to the computer-display console backed up by massive data banks.

Not only that, data banks will contain aids to decision makers; as noted earlier it will enable this group to more effectively draw upon world-wide expertise. A more consistent use of the "systems approach" will become almost mandatory (Reinschmdt et al., 1977).

Developing countries, through better contacts, will more and more realize that they don't have to repeat the mistakes made in the older cities of industrialized nations. Unfortunately the transfer of technology will not proceed at a fast enough rate, even though such exchange of information is of crucial importance (ASEE, 1975).

International Cooperation (A1) There will be more international cooperation. It is a necessity for survival. As Asimov says (1976):

> "What about the year 2000? Human civilization will be fighting for survival. There will be few leaders who fail to understand that the only hope of escaping total collapse will be cooperation among nations. In the course of the next two dozen years, assuming no overriding breakdown of world society, more and more of the world's problems will be overseen, evaluated, and as much as possible controlled by international bodies."

The Council on Tall Buildings and Urban Habitat, an international forum sponsored by engineering, architectural, and planning professionals, was established to facilitate such evaluation and exchange. One of its major efforts is the preparation of a MONOGRAPH on the subject, to be published by the American Society of Civil Engineers in 1977. A number of its chapters have been cited above. As first of all a compendium of knowledge about tall buildings, it calls to attention and documents the many different things that need to be considered in the design of a high-rise building. It contains research needs; it contains extensive bibliographical material. Its input is from a major international conference (Joint Committee, 1973) and from 38 regional conferences held in 30 different countries (Schulz and Peterson, 1976). It has contributions from 850 specialists from 50 countries.

And what lies ahead, beyond the MONOGRAPH? Just as life is a series of new beginnings, so also the completion of the MONOGRAPH provides a new challenge. The accumulated mass of information is considerable -- and must be used. The data base needs to be expanded and made generally available. Evident gaps in information required for decision-makers need to be filled through the conduct of new research. Other significant areas of research, identified in the preparation of the MONOGRAPH, need to be stimulated within the usual research agencies. The urgent needs of housing require attention. The role of tall buildings in developing countries is an emphasis that can help the millions achieve a better standard of urban life.

Conclusion. What will all of this mean to the structural engineer?

1. It will mean more cooperation with other professionals. There needs to be developed a familiarity with those professions and full mutual respect.
2. It will mean a realization that the building is part of the total system. It is "connected". The principal connections are to transportation, power, water, and waste, to which must added the multiple services (health care, labor, food service, supplies, postal service, security), and other amenities. The interactions of the buildings with all of these sub-systems, coupled with problems of the environment and land use, create a new concept and approach.
3. The design team must be especially sensitive to the needs of the culture for which it is designing.
4. Finally it will mean that a sense of awareness of the impact of technological creations must be both cultivated and maintained.

Perhaps even more important than these is the extent to which the engineer acts out his role as citizen. As the mayor of a large city in the USA said,

> "These problems are not all for the engineer to solve with his slide rule; they are something the engineer must face as a citizen, a man, a humanist. I see as much need for him in politics as in his normal pursuits." (Jonsson, 1969)

It was summed up by Furgler (1973) at the Swiss Tall Building Conference when he said,

> "A lot depends on personal courage ... Government and the (design) professionals must become partners in the solution of regional planning problems. And the designers should take the trouble to explain the options at home -- and to their friends."

The plea is for sensitivity to human reactions. Because in the final analysis human reactions will control the built environment.

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