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PREFABRICATION OF BUILDINGS AND ITS INFERENCES UPON
THE DEVELOPMENT OF LATIN AMERICA

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I. COMMENTS ON DEVELOPMENT AND LATIN AMERICA

One of the most remarkable features of economic activities in Latin America, at the present time, is the vast effort which the Hemisphere countries are making towards reducing their present state of socio-economic under-development in relation to more advanced countries.

The extraordinary results achieved through scientific research and invention techniques, coupled with the amazing technological progress of today, have had a great impact on the development process of all nations.

Consequently, there is a longing for well-being among all communities, which is a direct consequence of their awareness, through all existing modern media of communication and information of the benefits which progress can provide.

Day by day, Latin Americans are becoming aware that only through an overall development and an immediate and sustained utilization of all scientific and technical resources will it be possible to ensure the needed production of goods and services, both in quantity and quality. When this is finally accomplished, it will be possible to build up a juster society where people will not be so impoverished and living conditions will be compatible with the dignity of human beings.

Yet, one must recognize that the use of technological innovations is by no means an easy task, inasmuch as it requires sizable investments, favourable structural conditions and a suitable level of vocational training. Because they are not aware of the particular leading features capable of promoting development, underdeveloped peoples will often unconsciously create barriers to an improvement of living standards, so eagerly desired by everyone.

/Brazil's total

Brazil's total area of 8,500,000 square kilometres is scantily inhabited. It is estimated its population density will reach 11.2 inhabitants per square kilometre by 1970; the vast internal migratory movements give rise to increasing urban concentrations. This country possesses a vast potential of resources still to be developed, but her political and socio-economic structures have peculiar characteristics; therefore the country requires specific and regional solutions to solve its problems, though such solutions differ from those deemed more appropriate to other Latin American countries.

Nevertheless, there is an aspect which is common to all Latin American nations, i.e., the lack of adequate savings with which to build up the needed capital and an inefficient approach to meet their socio-economic development requirements. Average earnings in the lower income brackets, barely sufficient to provide for the subsistence of large segments of the population, result from the prevailing slow rate of development. The negligible savings resulting therefrom fail to generate the appropriate resources needed to improve productivity and boost the development process of these nations.

Unless this vicious circle is broken, Latin American populations will never be able to achieve the benefits already available to other peoples who have made use of scientific and technological advancements. Such benefits are today a tangible reality and are desired by everybody else.

It should be noted that to save does not necessarily mean to quit buying consumer goods, but rather it means to abolish waste, and consequently to make a better use of available resources and try to secure the maximum return from investments made. Whenever new combinations of production factors are made it is the same as creating a new efficiency generating mechanism for the production system.

Economic development, which makes it possible to improve the living conditions of the populations, signifies that production factors have necessarily to be restructured. In other words, production and productivity must gradually increase.

/Increased productivity

Increased productivity is today a primary preoccupation in development processes, for the growth of the overall productivity of a country brings forth the improvement of the peoples' well-being.

Latin American peoples will therefore have to choose between those policies capable of promoting the necessary expansion of production. Such option should consist of a rational choice of modern techniques. Solutions should be adopted which will necessarily lead to both an increased efficiency of the system and a simultaneous and sustained utilization of the available labour force.

Yet, to produce for the sole purpose of making use of non-skilled labour may be the right approach in certain periods of History or under given circumstances, but this should never constitute a long-range goal, nor a solution for an overall and sustained improvement of the populations' living standards. Such decision might even give rise to serious consequences because of the reversed role played by manpower in the process of development, and to an unfavourable reaction to scientific and technological advancement. This might even impair the chances of attaining the major goal of maximizing the supply of goods and services at lower costs. Summing up our views, we should like to recall that "the only means available to Mankind to secure better living conditions is to improve production methods".

It is always difficult to figure out quantity-wise the best way to attain a high level of manpower employment and a comprehensive utilization of available resources, because processes function dynamically in various multiplying sectors of economic activities and at different times.

The basis for creating new jobs is inevitably found to be that of instituting incentives to foster the efficiency of the development process.

Only careful socio-economic surveys and accurate studies on capital return can determine suitable, technical and feasible alternatives capable of providing greater benefits to communities in the short run.

If the final goals are to be achieved, it will be necessary to establish evolutionary stages for the development process, and to determine the optimum utilization of available production factors and the strategy to be followed.

/Adequate policies

Adequate policies of economic development may constitute an efficient instrument to satisfy the peoples' aspirations for development. However, these policies should be implemented on an overall basis and not on an interim basis. Although interim solutions could yield satisfactory and sectorial results, they might in the long run turn out to jeopardize the attainment of the major goals.

II. THE HOUSING POLICY AND LATIN AMERICA

It seems obvious that the housing policies of developing countries should by all means be compatible with those of overall development.

Thus, the solution of housing problems in such countries should not consist of the import of production goods to meet immediate requirements. Likewise, it would not be appropriate to commit either one's own or external resources to large expenditures, such as that of importing costly machinery without a corresponding assimilation of the pertinent know-how. Also, it might prove highly inconvenient to simply choose conventional methods of construction from among those which draw more heavily on idle manpower, as this would signify a lesser capital-labour ratio and of course less efficiency.

It would not seem logical to ignore all the lessons of modern technology just as attempts are being made to meet one of man's primary needs, namely, that of living in decent housing. Likewise, it would not seem logical to fail to use such lessons in the production of food for the needy. It would be like refusing to adequately meet another primary human requirement - living - "an original requirement of which all the remainder are but mere consequences".

The history of human progress is in the long run nothing but the advancement of man's intellectual capabilities toward satisfying his own well-being needs.

One should bear in mind that the major goal of any National Housing Programme is:

"To build more houses in shorter time, at lower costs, and with improved conditions of quality, comfort and durability."

/To this

To this end, it is imperative to expand production through the use of modern building methods, and to shorten construction times, as well as to increase productivity indices.

The need for additional housing is not merely a consequence of population expansion, with its resulting industry concentrations and urban clusters, but also a consequence of the gradual improvement of the living standards of the peoples, which tends to keep up with economic development. An overall socio-economic improvement results in a search for new, improved and better-equipped dwellings. An enlightened community will in time ask not only for shelter, but also for better living conditions, for which more elaborate urban development and architectural plans will be required.

Additional housing construction will therefore have to grow at a rate higher than that of population increase, thereby giving rise to the emergency of new production problems hitherto unknown. The coexistence of all these factors resulting from the need and a continued longing for development will cause contractors to try and learn the lessons of other peoples, and ultimately go through a revolutionary stage. Then, they will substitute modern industrial construction processes for their conventional methods.

In seeking a solution to problems involving the industrialization of housing construction in Latin America, special emphasis should be given to the varied regional conditions. However, one should make the most of the experience of other nations, with all its rights and wrongs. This would be the best way to reduce building times and a short cut towards solving our housing problems.

III. INDUSTRIALIZATION OF CIVIL CONSTRUCTION

Adequate measures to increase productivity in housing construction may lead to spectacular results in our country, as was the case with practically all developed nations which succeeded in increasing the number of houses built, cut down costs and shorten building times.

Surveys conducted by us reveal that in Europe there is an industrial concept common to practically all building methods. The most important peculiarities are to be found in the different methods of manufacturing

/building components,

building components, their degree of mechanization, organization of plants, whether fixed or mobile, and the efforts made to find new materials to be used.

Construction industrialization, as it exists in developed countries, is the result of the necessary demand for optimum building conditions, by means of a detailed and methodical preparation of the work. It is intended to adapt industrialization to modern economy and to technical-scientific advancements, now fully utilized in other industrialized activities. Obviously, it became necessary to previously plan the organization of all activities related to the art of building, ranging from the programmes, studies and projects to actual construction on the work site and an overall use of up-to-date mechanized equipment throughout all stages of construction. Looking at the problem of housing construction from an industrial viewpoint, the following well-known equation is applicable:

$$\text{INDUSTRIALIZATION} = \text{RATIONALIZATION} + \text{MECHANIZATION} + \text{AUTOMATION}$$

Rationalization: an effective utilization of production means achieved through careful planning; Mechanization: utilization of mechanized processes capable of producing prefabricated construction components; Automation: mechanization of planned intellectual tasks.

Large-scale industrial production causes the industrialist to plan his future programmes carefully and scientifically. Then it often becomes apparent that difficulties are not restricted to securing skilled labour of financial resources, but especially to the administrative ability to rationalize the utilization thereof. Needless to say this rationalization is not contingent upon the construction process, for it is just a part of the industrialization process.

The overall increase of productivity in the construction business already achieved in practically all countries which took a firm approach toward the housing problem was unquestionably a consequence of mechanization. Mechanization is not only a means to cut down costs but also, for several reasons, a real need to all current construction projects offering minimum conditions for the applicability thereof.

As we stress the importance of mechanization within the equation above referred to, we are not specifically referring to the use of power shovels, concrete mixing plants or derricks, for this type of equipment

/is generally

is generally used in conventional building projects, but rather primarily the processes used in the fabrication of the different prefabricated building components. The degree of mechanization of a given construction project may be correctly evaluated by the ratio between the cost of the components manufactured industrially and total building costs.

IV. OVERALL PREFABRICATION OF BUILDINGS

The overall prefabrication of buildings in large reinforced concrete panels is one of the most adequate forms to industrialize construction, for it necessarily applies the principles of scientific organization to mechanized housing construction processes. There must be a minimal level of continued production supplemented by adequate modular co-ordination in light or heavy prefabricated construction projects, such as it occurs with all types of industrialized techniques, in order that an adequate productivity rate may be achieved. It is the combined effects of market continuity and repetition of building styles which determine the best conditions for a low-cost organization of production in large industrial series.

Industrial prefabrication processes have their own systematized technique which differs entirely from that used by us in the housing sector, and in which important design problems are routinely solved along the period of construction, with loss of time and cost increases.

Basically, these processes consist of the fabrication of largely used building components, which upon completion are moved to the work site and erected with the aid of derricks. Beams, interior and exterior wall panels are large reinforced concrete (ordinary or light) pieces with hollow or massive bodies. Door and window frames, electrical, water supply and sewer piping and the plastered surfaces are incorporated to the prefabricated panels and readily placed into position. Staircases are also prefabricated in reinforced concrete panels and readily put into position. Peculiar skills are used so as to provide for a monolithic structure and waterproof construction joints.

Prefabrication processes are not likely to become obsolete nor are they limited to small groups of building styles, inasmuch as one may change the qualities of materials to be used in the prefabrication of panels or in the finishing touches, according to project specifications.

/These building

These building methods call for a very strict overall planning, beginning with the draft project and going down the line to include every building phase. It can be said that prefabrication supersedes empiric and outmoded processes, and creates conditions for use of new skills and processes which, based on mathematical theories recently developed but already proved in practice, ensure better economic earnings.

In fact, operational survey techniques are today effective management policy-making mechanisms. This complex of modern techniques permits a reduction in costs and in building times through the use of available factors and adequate planning, co-ordination and control.

Several methods used have proved so helpful and productive and have consequently become very well-known, namely, Linear Programming, CPM (Critical Path Method), PERT (Program Evaluation and Review Technique), simulation method and inventories theory.

In addition to linear programming, favourable results can be secured from the use of the PERT and CPM systems. By means of a logical definition of a sequence of events, it is possible to determine the critical paths and to learn beforehand what are the resources needed in terms of quantity and the correct times, as well as the alternative conducts to be adopted in fortuitous cases.

Inventories theory is another highly efficient technique which affects one of the major sectors of business concerns, because it sets forth purchase or production policies based on the size of economic lots. Therefore it directly contributes towards securing overall minimum costs and a high economic yield for the production system.

Therefore, the technique of overall prefabrication which includes all modern skills, in addition to overall planning which takes into account all factors participating in the project execution calls for the advance preparation of the following studies:

a) Detailed planning of fabrication of panels and building components (frames, electrical and plumbing fixtures, etc.) to be incorporated to the building; an adequate daily work schedule should be established for the prefabrication plants (fixed and/or mobile).

/b) Planning

b) Planning of panel transportation and erection work establishing accurately the number of types of panels to be erected each day, as well as all the supplementary work to be executed later.

It is obvious that, under these circumstances, contractors can effectively rationalize the project execution and be able to provide accurate estimates of costs and building times, thus gradually improving construction techniques.

The overall prefabrication of buildings makes possible to work on a scientific basis, using less physical effort and getting better results out of the resources used. This building technique designed to make possible production of goods at lower costs, employs the principles of simplified operations and new methods, with special emphasis on job assignments, logical sequence of programmes, time and motion studies, adequate use of materials and equipment, physical conditions of work sites, quality controls and production quantity. Excellent economic earnings are then obtained as a result of the following factors:

1. Improved productivity indices and production rates;
2. Work simplification, smaller number of molds, frequent re-use of molds and suppression of centerings;
3. Concreting of all prefabricated building components into panel form on the spot, which affords greater operational comfort and better technical conditions than it would be possible to secure on their respective final positions at the construction site;
4. Erection of large panels through a sustained use of adequate lifting and carrying equipment.

The industrial processes of construction of buildings by means of large prefabricated panels are those which afford greater advantages for immediate large-scale utilization in Latin America, because they basically meet the needs of housing programmes and can be used with available resources.

Bearing in mind that capital formation potentialities are inadequate in developing countries, it would be advisable that, when capital investments are made, the limited technical capabilities of firms and local market conditions be carefully taken into consideration. Investments of capital should therefore be made orderly and progressively. Simple-type

/mobile plants

mobile plants to fabricate panels on construction site should be used originally. Later, when the market for prefabricated panels so warrants, comprehensive industrial-like fixed plants should be provided on adequate locations.

V. BRAZIL'S SOLUTION OF HOUSING PROBLEMS

In going over the reasons which led to the worsening of the housing problem in Brazil, one is likely to find multiple and historical causes, such as the country's population explosion, urban concentrations, inflation, rent freezes and last but not least the failure of the housing construction industry in developing its techniques. Such failure derives from the management outlook which originated and strengthened during the various periods of inflation and because management has never been much concerned over productivity increase and lowering of production costs.

Owing to the acceleration of the inflationary process, contractors were led to abandon the correct system of building on a job contracting basis and to switch over to the "administration" or "cost" system.^{1/} As a result, they were left with no further economic incentives to keep prices within reasonable limits or to improve building construction methods by making them more productive.

The detrimental effects resulting from this situation still persist and are well-known to everyone; cost inflation, which causes a considerable reduction in the number of construction projects; longer building times, which largely contributes to speculation in the real estate market. Concomitantly, rents have reached levels incompatible with per capita incomes, thus making the housing problem really acute for the entire middle-class population.

The National Housing Policy, the fundamentals of which were formulated through Federal Law N° 4.380 of August 21, 1964, is a fair and effective contribution which the Government of Brazil devised to help meet the social problem of providing decent housing to populations which grow at a very

^{1/} A building society organized by the future co-owners of housing units to be built, who hire the services of a regular building contractor at a given fee.

fast rate, thus creating larger and larger clusters. The aforementioned legislation is a first-class human mechanism, for it enhances the value of men and their families. The basic policy under that law is to provide for home ownership, in furtherance of the principles of social justice and wealth distribution.

The National Housing Plan institutionalizes the Housing Financing Programme, and its main executing body is the National Housing Bank, which adopts the monetary correction of the debit balances of real estate mortgage loans. The Bank has definitely installed an organic and interconnected system which is highly efficient to help solve Brazil's housing problems.

Resources available under the Housing Financing Programme designed to facilitate and promote the construction and purchase of homes have been considerably increased through the added uses of the Length of Service Guarantee Fund, recently created by a federal law.

The National Housing Bank will manage this Special Fund (made up of 8 per cent deductions from all salaries and wages) and will borrow therefrom the funds required for carrying its housing building programmes.

It is therefore unquestionable that an adequate source of funds has been created capable of changing the substantial housing needs now existing into an effective demand.

Bearing in mind that in Market Economy price of goods and services are built up through an interaction of supply and demand, special consideration should be given to the economic aspects of the inevitable increase in the demand for additional housing now made possible by the availability of substantial financial resources. However, it is not true that once financing has been secured, all other problems will have been automatically solved.

What we deem as urgent and indispensable, in order not to restrict the Benefits of the National Housing Plan, so carefully prepared, is to check the rising prices by building additional dwellings, in substantial quantities and in shorter periods. Only in this way will it be possible to check the inflation of costs arising out of an increased demand which will most certainly continue to occur in certain markets not technically

/equipped for

equipped for mass construction. In fact, decreasing costs can only be secured through a mass production and a considerable increase of productivity, which is the preponderant consequence of the systematic and rational application of scientific and technological discoveries.

Important functions are therefore reserved in the said Housing Plan to the private sector of the entire construction industry. The mobilization of the creative energies of business concerns will largely contribute to the achievement of lofty political, social and economic aims.

The National Housing Bank has been continuously willing to give an adequate support to all firms which display their firm intent in increasing their production capacities consistently with improved productivity, in conformity with the Bank's request. By so doing, these firms will contribute to speed up development, and thus fulfilling their primary social role of helping to meet the vital human aspiration for better housing.

For the reasons stated above, the industrialization of building is a pressing need. Obviously, it is not an end, but rather a means of meeting the vital needs of communities, by making it possible for them to improve their living standards.

With the purpose of supplementing the reasons which show that it is right to adopt industrialized processes involving the prefabrication and erection of buildings in Brazil, we shall now discuss some other major points of the housing construction problem.

A. BETTER SOLUTIONS OF FUNDAMENTAL HUMAN LABOUR PROBLEMS

The introduction of industrialized processes in building construction has aroused controversy as to the occupational aspect of the substantial non-skilled manpower available throughout the country.

Those who favour the sole use of conventional construction methods just for the sake of making an adequate use of the available manpower, usually do not take into account the other economic aspects already referred to herein. Those who do so evidently attach a secondary importance to productivity increase and to the benefits derived from resulting cost reductions.

In Brazil today, it is noted that civil construction workers are becoming scarcer and scarcer, whereas non-skilled labour grows at a considerable rate.

The productivity level of most of our building construction workers is amazingly low, due to the lack of appropriate training which in turn stems from the inadequate number of vocational schools in our country, and also from the stoppage of the flow of European immigration. In order to afford fair employment conditions to Brazilians, it is imperative to resort to construction processes capable of changing work sites into actual training centres to enable a sounder and more comprehensive use of the manpower available throughout the country.

If the industrialization of construction is directed towards this goal it will become possible to readily and rapidly turn non-skilled labourers into specialists. The creation of new professions such as those of molders and erectors of building panels will provide better wages for this category of workers.

It is really illusory to think that skilled personnel such as plasterers, carpenters, bricklayers, etc., needed to expand building activities in Brazil are readily available, through the sole use of conventional building methods. It would not be inappropriate to state that failure to consider the insufficiency of skilled labour will eventually lead any housing programme, scheduled to be carried out within reasonable time, to limitations and possibly even to failure.

It is therefore imperative to start using new skills which would allow for a better use of the manpower currently available.

We must once and for all eliminate the erroneous concept that all that counts is the number of workers directly working at the construction site, whereas in fact it is the effects and repercussions on the various fields of activity of the national economy that are related to the number of dwellings built within a given period.

Owing to the important multiplying and accelerating effects which civil construction exerts over a great number of other sectors of human activities on which it depends, considerable opportunities for absorption of idle labour will be provided, chiefly by firms engaged in extractive activities, manufacturing, transport and production of goods and services.

/Furthermore, it

Furthermore, it would also be erroneous to assume that the use of prefabrication methods in Brazil is primarily designed to replace the conventional processes now in use. Much to the contrary, prefabrication will be just an aid, although a very important one, to the gigantic effort of meeting the actual demand for additional housing currently existing in Brazil.

B. IMPROVEMENT OF BUILDING TILES

The time element is extremely important in the implementation of the Housing Policy of a nation with such an extremely high housing deficit as ours, where adequate financial resources for housing are still not available, interest rates are high and inflation still undermines our economy. In housing construction, it is also imperative to apply the principles of work organization and make use of operational surveys, both of which have been so helpful in the advancement of industrial activities.

Sub-ordination of productive activities to the "rate" principle was the major and best contribution to the improvement of industrial productivity achieved by Ford as he started to use mass production methods in his plants. The mere use of the "rate" concept in production largely increased the system's efficiency, resulting in lower production costs and bringing about a dynamic state of mind which ultimately became an additional factor of efficiency.

This and other experiments go to show that it is quite possible to achieve better economic results just by using new work methods.

Reluctance to use new methods to build in shorter periods is only shown by conservative executives who do not wish to take the risks posed by the use of new methods. We are therefore at a loss to understand why the extremely helpful and efficient production "rate" method could not be applied to help in solving the housing problem. It is unquestionable that the processes of building prefabrication are perfectly suitable to this important aspect.

It cannot be over-emphasized that economic development is a chain reaction brought about by overall changes of features and uses of technological methods. Shorter building times would bring about a major

/improvement in

improvement in the meeting of communities' requirements and would help to speed up the dissemination of the savings concept among substantial segments of the population.

C. COST REDUCTION RESULTING FROM SHORTER BUILDING TIMES

Cutting down the cycle of building times corresponds to providing a larger number of housing units to the communities. Because of the high turnover thus made possible, a given capital investment would make it possible to turn out more goods. In short, this would signify a considerable reduction of all costs which grow in direct relationship to the time element, such as loan interest during the construction period, fixed charges (taxes and fees, administration charges, rents, etc), risks of fluctuation of market prices and others, not to mention the advance completion of housing units thus permitting their occupancy.

As an illustration of our remark, there is quoted below an example wherein a comparison is made of the different costs of a given construction project if completed within 12, 24, 36 or 48 months. With a view to simplifying our presentation and calculations, we shall use the figure 100 to represent the total construction cost exclusive of the administrative charges; also, we shall consider the following as magnitudes which grow in direct relationship to the time element:

1. Administrative Charges (AC);
2. Monetary Correction (MC);
3. Interest on total cost (I);
4. Location value of construction project (LV) - to be assessed upon completion and release for occupancy.

We shall assume the following values for said magnitudes:

1. 0.4 per cent on total cost (100) per month;
2. With a monthly rate of 2 per cent;
3. With a monthly rate of 1 per cent;
4. Assuming that the minimum time limit for a given construction project were 12 months and that, upon expiration of said time limit, his house would have a location value of 1 per cent per month calculated on its total value (total cost plus administrative charges).

/The following

The following equations, which may be easily solved mathematically, relate the above mentioned magnitudes to the T period of the construction project, in months:

$$1. AC = 0.4 \times T$$

$$2. MC = \left(\frac{100 + AC}{T} \right) \left[T \times (1.02)^T - \sum_{n=1}^T (1.02)^n \right] \text{ in which}$$

n represents a generic month.

$$3. I = \left(\frac{100 + AC}{T} \right) \times \left[\sum_{n=1}^T (1.01)^n - T \right]$$

$$4. LV = (100 + AC) \times \left[(1.01)^{T-12} - 1 \right]$$

For the established time limits:

$$T_1 = 12 \text{ months; } T_2 = 24 \text{ months;}$$

$$T_3 = 36 \text{ months and } T_4 = 48 \text{ months, we shall get:}$$

Times (months)	AC	MC	I	LV	Total	Total value construc- tion	Percent- age indices
12	4.80	13.45	7.10	0.00	25.35	125.35	100
24	9.60	36.77	14.78	13.97	75.12	175.12	139
36	13.20	65.42	23.80	31.05	133.47	233.47	186
48	19.20	107.87	34.60	51.72	213.39	313.39	250

What we are trying to show through this comparative chart is that, besides the direct advantages deriving from the reduction of the production/marketing cycle, total costs grow actually in relationship to the increase in building times. The per cent indices shown above leave no margin for doubts.

Should we compare the normal times of a construction project carried out by conventional processes with those that may be achieved when using the overall building prefabrication method, we would see that the relationship of production rates can easily reach 1 to 4, which signifies a cost ratio of 1 to 2.5.

/Figure I

Figure 1 represents graphically the variation of these magnitudes, individual and accumulated, as related to the building time.

D. QUALITY IMPROVEMENT

Because it necessarily involves organization and specialization of work, technical concepts, adequate planning, higher productivity indices and optimum working conditions as well as the possibility of an easy and strict control, prefabrication of buildings will inevitably lead to an improvement in the conditions of comfort and durability of constructions.

VI. PARTICIPATION OF A PRIVATE COMPANY IN PREFABRICATION ACTIVITIES IN BRAZIL

With a comprehensive picture of the housing problem and an understanding of its inferences upon the economic development process of the country and quite aware that private enterprise had the duty to co-operate in the implementation of the Government's Overall Housing Programme, our firm resolved to introduce in Brazil the process of overall prefabrication of buildings by means of large reinforced concrete panels. This decision was in keeping with the policies set forth by us and already referred to elsewhere in this paper.

To be able to introduce this particular building process in Brazil, we first sought in Europe for those techniques which appeared to us to be more useful and more adequate to the existing conditions in Brazil. By adopting a technique already successfully used in other more developed countries, and by making the necessary adaptations thereto, we resorted to a clear-cut, time and money saving process in the important sector of research for new production methods. We sent our engineers, architects and construction supporting personnel to France, Switzerland and Italy for short-term training programmes, and thus succeeded in absorbing modern skills. In this manner, we were able to prepare specialists in prefabricating and train instructors who, back in Brazil, prepared the teams and created conditions suitable for development of the prefabrication process, using the resources available to us. Appropriate solutions, perfectly consistent with regional conditions, were studied and subsequently put into operation successfully by our firm.

/We first

We first used our above-mentioned process in a housing project made up of 252 apartments, built in 1966 for the Guanabara Housing Co-operative, a financial agent of the National Housing Bank.

Although we were quite sure about the advantages of our process based on the successful experience of other peoples we were cautious enough to develop our process in an orderly and progressive manner and first used mobile plants to fabricate the panels right on construction sites, bearing in mind the limitations of management capacity and local market conditions. We did so with a view to cutting down industrial risks and investment costs, and refrained from assuming sizable financial commitments as this might impair our preliminary financial results.

A similar approach was employed by us when it came to building the second housing project, consisting of 192 apartments, also for the aforementioned Co-operative.

However, we changed our policy when we planned the execution of the third housing development, consisting of 30 buildings and 472 apartments, which is currently underway, for sale directly to the public. This project is financed by COPEG - Crédito, Financiamento e Investimentos S.A., also a financial agent of the National Housing Bank.

Considering the flexibility of our prefabrication process, and based on the experience already acquired by us, and dealing in a really expanding real estate market, we projected a mixed system involving one fixed plant and various mobile plants installed on construction sites. A diagram of said system is shown on Figure 2.

The criteria of executive complexity and weight evaluation of the building components to be transported will determine the different styles and quantities of panels to be built by the fixed plant and by the mobile plants. The use of operational survey techniques, on the other hand, will determine the most economic methods, having in view the features of the market and of production and transportation of both raw materials and components and of the panels proper.

Practically only the front panels prefabricated in the main plant are hauled to the construction site in specially adapted trailer trucks, which are produced domestically.

Infrastructures of the buildings are constructed by conventional processes. Their type varies according to the natural characteristics of each case. Superstructures are constituted solely by large prefabricated panels (interior walls and beams) with structural functions and monolithically interconnected by means of small local concreted parts. Partitions, front or exterior walls and the other prefabricated components with no structural function are also perfectly interconnected. Different methods are used in the vertical and horizontal joints, all of which are perfectly waterproof.

All prefabricated components are erected and placed into position by means of derricks with different capacities of cargo lifting and reach, all locally manufactured. The facility and speed with which panels are erected depend upon the specifications of the derricks and on the quality and the degree of dimensional precision of the prefabricated components.

In our projects, the final step of construction is still carried out according to conventional processes. However, prefabrication simplifies this work, because it not only cuts down the number of needed operations but also makes it possible to use new and improved methods.

The productivity achieved through this process has gradually given rise to more and more significant results as teams acquire a better training.

It would be wholly unrealistic to try and compare man-hour indices per square metre in housing construction, unless the composition thereof has been previously determined. The great number of different construction methods, whether or not using industrialized and finished products, causes a substantial variation in the number of hours worked at the construction site. Not only the serviceable area, but also the space and the quality of construction should be compared. The indices used should also include other important aspects of the housing units. For instance, it is basically necessary to determine the quality of dwellings having in mind human requirements, both as to the tenantable aspects (acoustics, heat, lighting, ventilation, volume, esthetics, safety, passageways, etc.) and economic aspects (durability, construction and maintenance costs).

/What we

What we aim to point out is that the importance of using more productive processes cannot be adequately evaluated in a superficial analysis through individual indices, unless the other points of architectural concept and construction quality are also appreciated.

Regardless of the presentation of questionable indices, we can safely affirm that, after building several hundred apartments by the overall prefabrication process, such process is economically adequate to conditions prevalent in Brazil. It is capable of favourable competing with traditional construction methods from the standpoints of direct costs, building times, comfort, durability and maintenance of housing units.

The recognition that prefabrication is par excellence an industrial process has made it necessary to reorganize our firm structurally, and to create conditions compatible with the economic and technical benefits and the high earnings afforded by this process. There would inevitably be limitations to the extraordinary capabilities of our process and to financial results had we not rationalized our organization and had we stopped using the new concepts of scientific administration.

Before long, as we start the electronic processing of our data, we shall be able in less time to perfectly determine the most economic methods and to rationalize and mechanize our administrative tasks thus further increasing the overall efficiency standards of our production processes.

One important point which is being worthy of general attention in the entire community is the favourable state of mind, the dynamism, optimism and confidence in the possibility of building a better future through the use of new processes which include modern technological skills and which step up the rate of production of goods.

We have always firmly believed that the whole range of scientific and technologic knowledge amassed by mankind over the years should be effectively used in such a manner as to benefit man and provide an overall well-being. Therefore, we have continuously had in mind that all business concerns should be organized as economic units so as to fulfill their basic role of Rendering Service, by soundly satisfying the needs of human communities and furthering the assistance rendered by their collaborators.

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The sound and smooth joining of CAPITAL - MANAGEMENT and LABOUR in the production duties and in the sharing of earnings readily allowed us to reconcile the efficiency of new skills with social justice. We have given one of the most significant examples of what a private company can do to break the vicious circle of underdevelopment of our country.

VII. CONCLUSIONS

We believe it would be very opportune to recall some interesting conclusions arrived at by the Economic and Social Council of the United Nations in a conclusive report on the alterations needed in the structure of construction industry for improving their efficiency and increasing their production, submitted by the Economic Committee for Europe (Prague, April, 1964) such as:

- a) Acknowledge as a fait accompli that it is necessary to industrialize construction so as to fill the gap between social needs and the capabilities of the building construction industry;
- b) Acknowledge that social needs should be evaluated not only in terms of quantity, but also of quality for an established cost;
- c) Special attention should be given to construction designs and to the building as a whole, so as to perfect the quality of human environment;
- d) Consider that the development process should take into account man's needs, as well as technological processes;
- e) Acknowledge the need to adopt a system of dimensional co-ordination;
- f) Consider it would be helpful to be able to evaluate construction in economic and functional terms, so as to allow for correct comparisons of construction methods;
- g) That substantial benefits may be expected from seminars or symposiums that should be held from time to time, in which the views and experience of different countries may be exchanged.

The magnitude of the problem and the major political and socio-economic importance of its solution to Latin America makes it an imperative need to establish the means of soundly combining the efforts of Governments and private concerns.

/Recognizing the

Recognizing the inestimable contribution which work organization and industrial progress can make to the task of development and that liberal capitalism may fail to serve community interests, and further that Economics and Technique should always be at man's disposal; in order to actually turn from words to deeds, we deem it necessary for government agencies and private enterprises to be guided by the following policies:

1. Provide continuity to the application and development of housing programmes, by institutionalizing monetary correction, which are the sole instrument capable of helping to meet the vital need of adequate living, and of turning the sizable housing needs into effective demands for new housing.

2. Adopt modern and special construction processes confirmedly efficient which, by means of a considerable expansion of production and productivity will make possible to check inflation costs as these will inevitably occur as a result of the increased effective demand and also reduce the time limits for the building of new housing.

3. Seek for scientific and technological knowledge in other countries with a view to cutting down building times and resources which otherwise would be spent in the performance of expensive research of new construction processes.

4. Set up actual training centres of construction sites to train non-skilled workers and turn them into specialists as rapidly as possible.

5. Support and stimulate by means of credit and fiscal incentives all construction materials manufacturers, thus rendering it possible for them to produce more at lower costs.

6. Acknowledge that overall prefabrication of buildings into large panels, because of its industrial features, fully meets all the above mentioned technical and economic requirements and that, therefore, its expansion should be widely supported and stimulated by the Governments.

7. That, in recognizing the risk of formation of monopolies by those firms which use this highly productive process, Governments should provide incentives, through adequate legislation, to those companies known to have been organized to SERVE the communities and which, by widely disseminating co-ownership principles through public participation in their capital stock actually operate as economic agents in the distribution of wealth.

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Should these guidelines be fully adhered to, there will be a real interaction between the Government and private enterprise, which it is expected will make it possible to meet in no time the lofty goals of housing programmes and to provide adequate solutions to the crucial problem posed by the lack of new and decent housing.

The stepping up of the process of housing construction, in keeping with the socio-economic policies herein recommended, will signify an increase both in terms of efficiency and of savings, thus resulting in the country's economic expansion. This would constitute a power mechanism to break the vicious circle of our underdevelopment and would contribute towards the achievement of COMMON GOOD.

STUDY OF THE INFLUENCE EXERTED BY BUILDING TIMES ON TOTAL COST OF CONSTRUCTION PROJECTS

ESTUDO DA INFLUÊNCIA DO TEMPO DE EXECUÇÃO NO VALOR TOTAL DA CONSTRUÇÃO

