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LOW-COST BUILDING MATERIALS
TECHNOLOGIES AND CONSTRUCTION SYSTEMS

DP/RAS/82/012/11-55

Technical report: Implementation of modular co-ordination in building in Malaysia *

Prepared for the Government of Malaysia
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Mr. Marc Pelce
consultant in industrialized building

Backstopping officer: B. Der Petrossian, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

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SUMMARY

The mission described in this document included 2 sorts of objectives.

For Unido, it was to obtain data on Malaysia's capacity and motivation for the development of industrial production for low cost housing. The visit of five plants showed that there seems to be no problem from the point of view of know-how and the quality of the production tools, though the problem of the investment capacity remains.

For the Malaysian Authorities, the aim was to assess the progress and nature of the work for the development of the use of modular coordination, to offer working directions, and to offer their technical assistance to the implementation of standards opening the way to an industrialization of construction.

The mission has brought to light the evolution of the program's objective, which turns towards open industrialization. To achieve this, it is necessary to proceed with some research on assemblies and joints; to avoid going too far in preferential dimensions, and to tie closer links with the industries.

1M$=.4US$ (February 1987)

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INTRODUCTION

For faster and cheaper building, a way is often taken with success: it consists in encouraging the production of industrialized housing. Part of the hazardous work on site is transferred to the manufacturer of components who executes it in the conditions of quality offered by a plant.

Several situations coexist in the industrial solution: either to produce a high number of identical housing with the same technology. This is closed prefabrication. Or, on the other hand, produce catalogue components compatible with these of other manufacturers: this is the concept of open industrialization, offering a variety of designs.

Malaysia has chosen the latter. However, in this country there does not yet exist a genuine industry of components, it is therefore necessary to incite the private sector to invest.

But in order to produce compatible components, designers and industrialists must apply a number of rules said "of dimensional coordination".

Banking on an incitation by Demand, the Malaysian Authorities encourage an implementation of coordination for the greatest number possible of projects, thus opening a market for potential component manufacturers.

This intention founds expression in an intensive three year programme (1986/1988) for the extension of the use of the rules of modular coordination.

This three year programme plans to resort to foreign consultants, familiar with these questions, who can offer local operators the necessary technical assistance. After this program had been followed for one year, the aim of the mission was to:

- examine the progression of work planned and give their opinion on the content of documents realized, under way or planned,

- analyze the planned programme and suggest necessary adjustments

- assess the country's capacity to start on an industrial production of components.

This month-long mission was divided into three parts. First, the Malaysian Authorities sent the expert for his prior study, a month before departure the completed work on which the critical examination and commentaries were to be made.

The part on the spot led to the confrontation of opinions and remarks with their authors, and to organize an information day on the theme of dimensional coordination. Also in Malaysia, five visits of plants and realizations were effected in order to assess the capacity of the sector to start with the industrialized production of components.

The third part allowed the compilation of.additional data necessary for the completion of the study and the realization of this document.

From the point of view of results, the information obtained during the mission, enabled:

- the drawing up of the technological know-how of the precast concrete industry in Malaysia,

- the assessment of the progress of the programme and a number of remarks and opinions on the work planned,

- a number of technical contributions when considered necessary in order to alleviate a difficulty.

I-GENERAL ISSUES CONCERNING UNIDO

A-Traditional techniques currently used in Malaysia

The development of industrialized building is still rather limited, except in certain important housing programmes near or in the large towns.

The traditional (or conventional) techniques the most extensively used include for the most part:

Walls

Hollow concrete masonry blocks which can be left without coating but can be painted. The other traditional technique consists in the completion of a beam/column concrete structure placed on site, with shells of full bricks of 6.5 x 11 x 22 cm type. This technique is more extensively used in collective buildings and buildings for other prurposes than housing (schools, shops, offices...).

Floors

They generally consist in full slabs of concrete placed in wooden moulds realized on order.

Stairs

They are of placed concrete or made of a steel string bearing wooden steps. It seems to be a more economical technique locally.

Doors and windows

Of local timber for low and medium cost housing. The design is rather simple because of the favourable climate. Neither sealing joints nor double glazing. The absence of size standards is deplored by contractors and manufacturers, for it engenders a near permanent production made to measure, which increases cost.

Framework

More and more industrialized, of timber for reasons of quality and speed of assembly. The frameworks assembled on site were often realized with timbers that were insufficiently resistant to under-roof temperatures.

Roofs

Preferably of concrete or burnt clay tiles (success symbol), or else of corrugated asbestos/cement, cheaper.

One must emphasize that the current low cost of labour always makes the traditional techniques more advantageous than industrial constructions. Two considerations can modify this situation:

- The traditional construction does not always have a good image, for there is no guarantee over 6 months, or 1 year. In a climate of increased competitiveness, small firms are tempted to build faster, without always respecting a minimum standard of quality.

- If industrial construction could benefit from a mass effect, for example with the production of compatible components on an open market, the cost obtained could be favourable to industrialized constructions.

B-Scale of values admitted between low/medium and high cost housing

Scale of selling price

NS 25 000		NS 100 000	
low cost housing	low/medium and medium/low cost housing		high cost housing

The NS 25 000 limit value for the low cost housing seems accepted by everybody. Between NS 25 000 and NS 100 000 different levels of medium cost.

Cost price of low cost housing

A 60 m² low cost sold NS 25 000 including land, road, water and electricity connections costs between NS 8 000 and 11 000. These values vary with the price of the land and the prices practiced by the local contractors.

Of this cost price, 75 to 80% concern the main structure and foundations. It is to be remarked that the finishings are somewhat rough (plumbing, electricity, paint).

The mean cost of the main structure, including foundations, can be estimated at NS 7 500 for a 60m² house, with :

NS 1 = US$ .4 we have US$ 50/m²

The break-even point of a plant for the production of components has been estimated at 3000 or 5 000 houses on the basis of these values.

C-Capacity of the country to implement industrialization of construction with compatible components.

1. Industrialization process currently encouraged by the Authorities.

The objectives of the 4th five-year plan (1981/1985) planned the construction of 923 000 lodgings, of which 266 500 would have been low cost.

Faced with the results, 406 070, of which 90 480 low cost, the Authorities decided for the 5th Plan to disengage themselves from construction, counting on the dynamism of the private sector to realize its programme.

The objectives of the 5th five-year programme (1986/1990) should be of 701 500 lodgings, of which 495 000 for the low cost - 80% of these realizations taken in charge by the private sector, that is 552 000 lodgings, of which 374 100 low cost.

The desired industrialization policy should aim at lower housing costs, while maintaining, indeed increasing its quality. However, this evolution must not be too sudden, to prevent any negative effects on employment. According to an estimation by the Ministry of Housing, out of 80 000 lodgings a year planned from 1987, half could be industrialized, of which 30 000 in modular coordination (cf below).

In order to develop the industrialization of construction, it is necessary that the private sector take in charge the construction (and the corresponding financial risk) of production centres for dimensionally compatible components.

But the private sector, before engaging itself, is waiting for a sufficient outlet to be perceived, indeed reserved, as conventional methods are still cheaper.

In order to break this "vicious circle", the Authorities bank on modular coordination. By developing the projects conceived according to the rules of the conventions for dimensional coordination, and realized for the time being with conventional techniques, the Authorities bank on an awakening of the private sector to the market engendered by this conception.

The key idea to be accepted is: Let us forget that a plant is necessarily attached to a project and let us build a plant for a market potentially open to all projects.

Admitting that such a demand should succeed, which are the components to be produced in the first place?

In vertical coordination, Malaysia only retained option 1 of the ACC rules (Association Construction et Coordination). For the technical reasons detailed in II A 1, this decision favours the production of prefabricated stairs and floors, subject to the definition of preferential sizes. It is therefore possible to imagine that the materialization of a policy of industrialization of construction should start with:

- the production of floors such as:
  - .full or hollow slabs,
  - .prestressed or only reinforced pre-slabs.
- one-piece stairs or stairs in elements.

2. State of the precast concrete industry in Malaysia

Throughout the 5 visits, the accounts of which are appended to this document, we have deliberately tried to extend the notion of component.

Indeed, the prerequisite for the technical success of a production of concrete components is the mastering of the material. All manufacturers having mastered this, are potentially capable of acquiring the additional know-how for the production of components.

The 5 plants (and realizations) visited cover the variety of productions usually encountered.

- a multi-product plant with delayed demoulding, the production of which began with pipes.

- A mono-process plant, with extensive automation, for a production of immediately demoulded blocks and paving blocks.

- A plant manufacturing components for a closed system.

- A plant producing hollow floor slabs of pre-stressed concrete, certainly the closest to the system currently followed by Malaysia for an open industrializaton.

- Finally, for the record, a building site with a sectional formwork, a process radically opposed to that of the components.

In addition to the impressions of visits, which, plant by plant, detail the important points, three common key ideas must be emphasized:

- The production tools exist: modern and well maintained, of foreign make, these tools are used with intelligence by an executing and executive staff of high quality. The organization of production always seemed very efficient. The existing production tool however has a production capacity far insufficient compared to the potential market.

- The same goes for the know-how related to the production. Be it at the designing level, the follow-up of the product's quality, the mastering of costs or the commercial dynamism, there seems to be no weak link in the chain.

- Finally, and uppermost, what is most remarkable is the capacity for diversification by the taking over of technologies from industrialized countries, even quite sophisticated:

  . pre-tensioning,
  . the automatic proportioning of water in the concrete,
  . the production of elements in GRC Spray and Premix,
  . the management of a production unit by a programmable automaton.

3. Construction of a plant: The question of its financing

If everyone agrees on the necessity of such a realization, none of the parties concerned is ready to be alone in assuming the risks.

The public sector is disengaging itself of an activity which it has left to the private sector. The local private sector is waiting for the emergence of a reserved market. The foreign private investors are waiting for the return of their capital, for the moment problematic. The international bodies (UNESCO, UNIDO, UNDP) first want to make sure that:

- the local participants are determined to know where they are going,
- exchanges are possible with neighbouring countries.

The joint-venture, which seems much practised in Malaysia could be used here, according to the following conditions for the investment in production tools:

- the public sector would bring the land and the viability,
- the international aid, the production equipment,
- the private sector the civil engineering and the staff necessary for the launching.

The private sector would then run it till break-even point.

D-The rules for dimensional coordination chosen by Malaysia compared to those used by other countries.

This issue was presented at the "Modular Coordination Working Group" on the 10th of February 1987.

Very briefly, the rules followed can be divided into three families:

1. The rules issued from Scandinavia (Finland, Denmark). Crosswalls and façades, centred, engender numerous and costly adaptation spaces. In order to minimize costs, it is necessary to determine the technology of the assembly. The system is closed, hindering any genuine competitivity between technologies. These are systems in which the design is dominated by the technology.

2. The Dutch rules: façades and crosswalls situated in the divisions of an alternate screen (TARTAN) which reduces the size of the numerous indispensable adaptation spaces. The system seems interesting at first sight for it is more open to a variety of architectural compositions. But it suffers extensively from the incompatibilities of certain techniques with noise, fire and structural requirements. In this system the technology is dependant on the architecture.

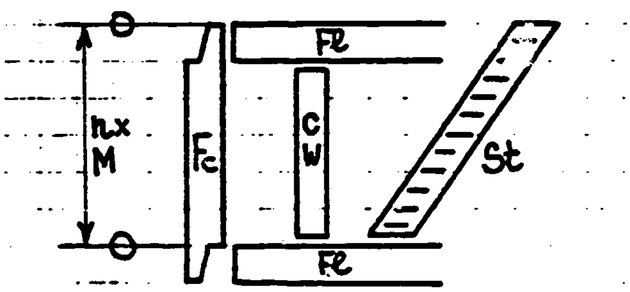
3. The ACC rules: the key idea consists in maintaining free modular spaces as long as possible. The successive sequences remain dimensionally coordinated, therefore open to all catalogue components available on the market. The determination of the technology, left to the latest possible moment, allows the economic confrontation of the greatest number of solutions.

II-ISSUES CONCERNING THE MINISTRY OF HOUSING AND THE LOCAL GOVERNMENT

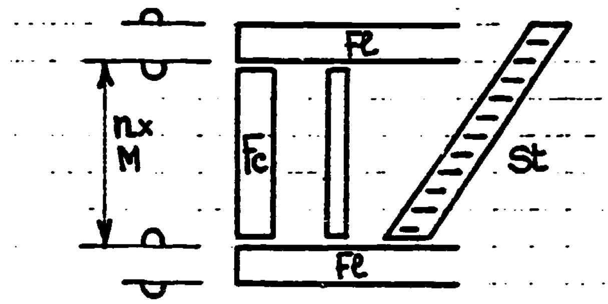
A-Analysis and remarks on the content of works executed, under way or planned

1. Decision to retain a unique option in vertical coordination

The principal difference between the rules suggested by Malaysia and the ACC rules resides in the selection of the sole option 1 for vertical coordination.



ALTERNATIVE 1



ALTERNATIVE 2

Alternative 1	
Running façades Staircase	*Coordinated*
Crosswalls Partitions Inserted Façades	*Not coordinated*

Alternative 2	
Inserted façades Crosswalls Partitions	*Coordinated*
Running façades Staircase	*Not coordinated*

SOLUTION ABANDONED BY MALAYSIA

Fig I, Key:
Fc = Façade
Fl = Floor
CW = Crosswall
St = Staircase

According to our interlocutors, the decision to retain only option 1 was motivated by the desire to simplify the process for designers.

The industrial consequences on the sizing of components (Fig.1) were clearly analyzed before the decision was made. Having beforehand started the industrialization process with floors and stairs (cf I C 1), it was logical to seek a rule which would favour these components:

- For the floors, the production having just started, it is possible (and desirable) to typify their width, without however hindering the process of open industrialization (cf. II A 2).

- For the stairs, it is clear that the adaptation spaces are costly and that it is preferable to keep the alternative 1.

- For the crosswalls, it is clear that the question of their height will be much simplified by a typification of the thickness of the floors. Moreover, these crosswalls are and will be manufactured in battery moulds, in which the height is very simply obtained with wedges placed at the bottom of the moulds.

Finally, our interlocutors emphasized that such a decision did not exclude an opening up to option 2 after 3 or 5 years if conditions justify it.

For all these reasons, and though such a decision may seem too constraining, it does seem adapted to the Malay context.

However typification of the floor thickness should be studied without delay.

2. Typification of thickness of floors and crosswalls

To proceed with this question, it is necessary to consider:

- the thickness of the floors according to span and overload,

- the existing technologies and those to be developed,

- the most frequently found spans in typical plans.

From an important sum of information, it is possible to determine statistically a number of spans which would be cheaper, in the case of loads from lodgings, for example.

As reference, we compiled and handed over to the Modular Coordination Working Group a file containing most thickness and span sizes from the French production of dimensionally coordinated floors.

We suggested to the group that they proceed with a statistical analysis of the spans on a significative sample, representative of recent projects. Without prejudging the results of this study, it seems that three typical thickness sizes should cover the majority of the needs.

3. Work to be done on vertical and horizontal joints

Fundamentally, this question does not concern the legislator but, as it conditions the sizing of the components, solely the producer who must ensure an obligation of results inside his sequence. This opinion was totally supported by one of the industrialists visited, who summarized it in the following formula: "joint is our own problem". However, as experience shows that this issue has not always been subjected to a sufficient degree of performance, it is useful to undergo a survey which would define the amplitude of the different factors of the local climatic conditions.

Very briefly, this study should concern:

- the local climatic constraints, particularly:
  . the differences of temperatures night/day, sunshine/rain,
  . the wind/rain concomittances,
  . the hydraulic shrinkage values in the local climate,

- the local cultural constraints resulting from the mode of living, notably the regular washing of floors to obtain the necessary coolness,

- the different joint solutions locally used or available on the regional market,

- the allowances admitted for the different manufacturing and processing stages of components.

- the impact of the nature of interior wall coatings

4. From the programming of a closed system to an open system

As it is presented, the three year programme for the implementation of modular coordination in Malaysia presents the advantage of a great rigour. With successive degrees of difficulties, from 1 to 2 storey houses to blocks of flats, via 3 and 4 storeys.

However, one must not forget that this programme had been planned at first for the implementation of a closed system of construction.

In these conditions, as a closed system engenders an important number of costly adaptation spaces, it is logical to insist in this programme on the necessity of determining a system of preferential sizes, step that artificially limits the particular cases.

Moreover, as in these systems the technology already exists, it is unnecessary to study assembly from an analytical point of view, as any change is excluded.

The new position taken by Malaysia is quite different. It has chosen rules for dimensional coordination which lead to an open system, that is:

- Which allows a dimensional compatibility of components from different manufacturers.

- Which delays as much as possible the choice of the assembly technology, to maintain their competition as long as possible.

Some corrections to the planned works then appear necessary. Essentially:

-If preferential sizes may seem necessary, particularly in the case of an industry of components that is just beginning, there may be more urgent priorities, for example contacts with industrialists (cf. II B 1).
Moreover, in open systems, all components pre-exist without the need to favour certain sizes.

- On the other hand, each time there is a genuine demand on the part of manufacturers and/or users, it may be necessary to undertake a standardization. Which seems to be the case now for doors and windows.

- Finally, and because an open system has been chosen, it is indispensable to proceed with a thorough study of assemblies.
This study finds another justification in the fact that it prepares the analysis prior to the establishing of a components catalogue.

5. Analytical study of assemblies

When rules for dimensional coordination have been established for an open construction system, one has the advantage of retaining the choice of assembly technology till the last moment, when all the possibilities have been envisaged from a technical and economic point of view. Till then, the situation of the connection must be analyzed as a space with a joint and a connection device.

- The possibilities of the joint position are not unlimited. The determination of the joint position results from a compromise between the manufacturer, the designer, and to a lesser degree the contractor.

- The technologies are not unlimited either. For example, there are about twenty in France, which can be regrouped in a few families.

The investigation to be undertaken on the analysis of the assemblies possible for the industrialized constructions in Malaysia should therefore include:

- A coding of the position of the assembly: using for example a cardinal marker, combined with a lateral marker.

- An analysis of the connection's morphology, showing notably the face of the assembly and the associated components.

- A state and typification of the technologies used and possible, with their conditions of compatibility with local conditions. Local practices will be taken into account for their typification

The summary of such a study of this sort,realized in its time in French, and for French technological conditions, and undertaken in view of its computerization has been handed over to the Modular Coordination Working Group.

In the absence of a definite computerized programme, such a study is however necessary because of the analytical rigour it imposes.

6. Current form of the examined documents

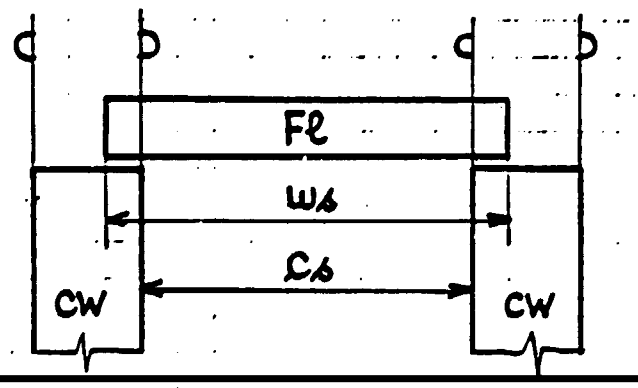
The modular design guide could be improved with certain minor modifications:

a) The plans 4100 and 4200 are European in their architectural inspiration and certain points could shock the Malay reader. It seems preferable to take a local conception.

b) The plans 4300 and 4400 include a number of overly free interpretations of the notion of technical spaces, which should be modified, notably for the façades.

c) Concept VI - Sizing of components
The drawing of the window does not clearly show the difference between:
. working size Ws
and . coordinating size Cs
It could be replaced for example by a floor.

Fig.2: Example of deriving work size (Ws)
from co-ordinating size (Cs)
with Fl = Floor; CW = Crosswall



B-Estimation and remarks on the three-year Malaysian programme for the promotion of modular coordination

1. Contact structure with components manufacturers

Figure 1 of the "terms of reference for the implementation of modular coordination in Malaysia" places the Trade Associations at steering committee level, with the evident aim of taking in the feed-back from the main participants concerned with the implementation of dimensional coordination.

During the visits effected in the 4 plants, of which 3 are already producing components, we noted the lack of relations and mutual cognition between representatives of the Ministry on the one hand, and the industrialists on the other. It did not seem obvious that the industry had adopted the governmental objectives.

The conference on the 18th of February 1987 was destined to representatives of the Ministry of Housing, architects and industrialists. During this occasion, we noted a lack of participation on the part of the industrialists in the debates, though they dealt on a subject that concerned them directly.

These three separate items show necessary it is to monitor contacts between members of the Modular Coordination Working Group before the term of the steering committee. It is essential that a permanent contact be established at the earliest in order to allow the necessary mutual feedbacks. It should be the MCWG's role to create a climate of confidence with these exchanges, bringing and spreading their knowledge through the results of their work.

This atmosphere of exchanges and confidence should become the best ferment for the development of the industrialized production of components.

2. Compiling the catalogue of components

The three-year programme represented in tables 3a and 3b of the "terms of reference..." does not include the establishment of the components catalogue, which is a necessary element for the creation of an open market of components.

However, in appendix D of the Modular Design Guide, item 4 System Analyst, the job description of the computer engineer is perfectly defined.

It becomes necessary to start work on the catalogue of available components. This work must not be understood as a review of the useful data on the products and accessories used in construction, but rather as a genuine catalogue of the available or potential components manufactured by the industrialists. Because of the limited current production, this catalogue can for the time being be presented on paper, which imposes a prior analysis, preparing its future computerization.

3. Computerizing coordination - Compiling the data base

The logic of computerization is unseparable from the notion of open industrialization. Indeed, for the mechanisms of the opening up of industrialized components on the construction market to function, it is necessary that:

a- there is a market for the components.
Malaysia is proceeding with an extension of demand through design according to the rules for dimensional coordination.

b- there is a corresponding and multiple offer, for the competition of technologies and costs.

c- It is possible and simple to consult the totality of the offer available on the market.

But the rules for the modular coordination imply that for a given component, staircases for example, there is a great number of different models, be it only by multiplying all the modular sizes possible in length, width and height.

The corresponding catalogue rapidly becomes difficult to manage or consult, but especially difficult to update as the components market increases.

That is why, the medium-term computerization of this data is essential. Let us note by the way that this method simplifies the increase of choices of preferential sizes because all possibilities can co-exist in the data base, if the production tool makes their realization possible.

Because of the limited supply in Malaysia, an immediate compilation of this data base is unnecessary. However, it is interesting to compile a manual catalogue which would be compatible with a medium-term computerized data base, which could be directly fed by the industrialists themselves.

Our correspondents told us on several occasions of the difficulties they encountered with the coordinating of a rough sketch in option 2. If one changes the thickness of a crosswall, the whole project must be gone through again.

CADD (Computerized Assistance for Drawing and Design) offers this new ease of design, by allowing this sort of returns inherent to the process of economic optimization. They can also be operated on low cost micro hardware, with which Malaysia is beginning to equip itself.

These softwares also have other possibilities, particularly for the optimization of the surface of rooms, very interesting in the case of low cost.

Briefly, computerization of the design and of the catalogue is not a tool reserved for countries that have long been familiar with it. It is on the contrary a mean which allows great speed, but also many other procedures impossible to realize manually.

It could be economically viable and stimulating, for a country starting on its industrialization, to invest both in the production of components, and in computerization of design. This investment stays minimal in view of local conditions. The skills required by the use of such systems are present at each stage of construction in the country.

C-Other Aspects

1. Coordinating plans of terrace-houses

One can estimate that at least 90% of individual houses are realized in the form of terrace-houses. For the sizing of the plots, it is the practice to divide the estate into lands the sizes of which are multiples of 30cm (3M). (It seems that the services concerned easily accepted the change from the 30.5cm foot to the 3M module of 30cm). Once they have been determined. these measures are definite, which creates an additional constraint for the sizing of the plans, therefore for the use of industrial components.

If option 1 (cf appendix B) does not offer any particular difficulty, option 2 on the other hand is more difficult to deal with though it is very interesting for inserted façades, frequently found in terrace houses.

With the experts on this question, we have to this effect compiled a note offering solutions to this question. This note, which has not been handed over to the Modular Coordination Working Group constitutes the appendix B.

2. Guarantees offered by the builder to the client

The guarantee currently offered by the builder is increasing from 6 months to 1 year. Which is not much, compared with the ten years in practice in certain industrialized countries. It was nevertheless sufficient while local practice offered a sufficient degree of quality resulting from tradition. With the gravity of the economic crisis, the market has been reduced and it was necessary to increase productivity, sometimes to the detriment of quality.

It is why it seems judicious to encourage a process which would progressively increase the guarantee, and could take place in two stages, of 3 then 5 years. Such an extension of the guarantee would be justifiable only if accompanied by a corresponding insurance system.

3. Seismicity of Malaysia

The resistance to sismical stress was evoked several times. Two points are to be considered:

a- Malaysia is not situated in an area of sismical risk.

b- The Tachkent earthquakes in USSR, and studies undertaken in Japan have shown the good behaviour of industrialized constructions in concrete during earthquakes, if they have been designed in consequence.

Indeed, the solution is not to create monolithic structures, but on the contrary strucures that can be deformed to stop the floors from slipping from their support.

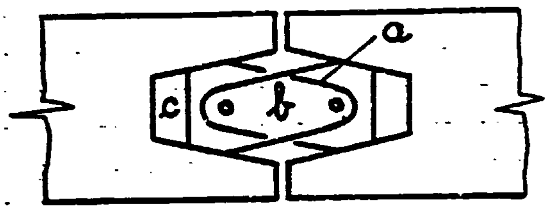


Fig.3 Example of a simple connection with a correct behaviour in sismical conditions

- the placed concrete (b) ensures the connection
- the keys (c) take over the sliding stress
- the bars (a) (for important deformation) ensure binding after failure

4. Problems posed by foundations

Our interlocutors stated a problem specific to the Kuala Lumpur region.

The capital of Malaysia was founded on a very important mining site for the extraction of tin (Malaysia is the world's first producer of tin).

The existing constructions have been realized on sound ground. The ground "on site" is in fact of very good geotechnical quality.

The land which is now available for low and medium cost constructions are those left, often on old mining sites.

The 6 or 12 month guarantees evoked earlier on are not very incitative for a sufficient settling of backfills, especially since the settling mechanisms are long term phenomena, which are not speeded up in Malaysia by winter/summer cycles

Moreover, there remain unfilled drives which cave in, and water pockets that render the ground unstable.

III - RECOMMENDATIONS

Recommendations are the following, numbered according to their decreasing importance.

A-Recommendations to the Malaysian Government

1. Proceed with a thorough investigation of assemblies and connections between components allowing:
   - a simplified analysis of connections independent of the technologies,
   - a drawing-up of available technologies and those to promote,
   - the assessment of the possibility and interest of a typification of the assemblies
   - the preparation of the computerization of the components catalogue.

2. Establish with the industrialists an original structure of permanent contact in order to:
   - receive the feed-back as early as possible,
   - create conditions favorable to the development of industrialization.

3. Undertake a study on requirements to which are subjected horizontal and vertical joints of façade components. This study should examine particularly:
   - the local climatic sollicitations,
   - the available technologies and those which should be created,
   - the allowances currently practised locally.

4. Offer preferential technical sizes for floors and crosswalls related to the choice of a unique alternative in vertical coordination. These suggestions must essentially be founded on an analysis of local practice.

5. Avoid an attitude too dogmatic in the field of preferential sizes, which could become useless because of:
   - a refusal on the part of the users,
   - the consulting of the catalogue.

   One should prefer a more pragmatic attitude of standardization corresponding to a genuine necessity; for example of doors and windows.

6. Prepare the compilation of the catalogue of dimensionnally coordinated components available in Malaysia. Undertake this task with the industrialists concerned (cf recomm. 2)

7. Plan in a further stage, a progressive transition to the computerization of coordinated design, then of the catlogue from end of 1987.

   For the time being, prepare this transition with the participation of the computer engineers in the work on assemblies and compilation of the catalogue.

8. Publish a simple and brief technical note on the application of the rules of coordination in the construction of terrace houses.

B-Recommendations to UNIDO

1. Facilitate the introduction of data processing of rough sketches and of the components catalogue with a financial aid for hardware and corresponding software.

2. Examine the financing possibilities of a typical plant for the manufacturing of industrialized components, in relation with the public and private sectors.

APPENDIX

APPENDIX A: Report of visits of 5 plants

Plant visited	PKNS PRATON HAUS BERHAD Lot 12 - Persiaran Selangor 40 000 SHAH ALAM	
Persons encountered	MOHD SUFIAN HASHIM	Site Manager
	BERTHOLD DE WEGNER	Project Manager
	YAACOB JAILANI	Production Manager
	HJ KUMAIRI B. DOLLAH	Administration Manager

PKNS, when it was founded in 1981, was the result of a joint-venture between PKNS and a German industrialist. It is now 100% PKNS. The plant cost M$ 10 million in 1982. It has since then produced 5 000 lodgings.

PKNS has a salaried staff of 350 for the plant and the site.

200 for production
 50 on site,
100 for the management, maintenance and adminstration.

Two manufacturing halls capable of producing 55m³ per station. The minimum strength of the concrete is 35 MPa. The products are manufactured on tilt-up tables in moulds made to order. Minimum for a project: 200 identical lodgings.

The production capacity varies between 16 low cost and 2 high cost a day.

The lodging surface produced are:

- low cost: $55m^2$
- cluster (low medium cost): $60-70m^2$
- medium cost: $110-146m^2$
- high cost: $160m^2$

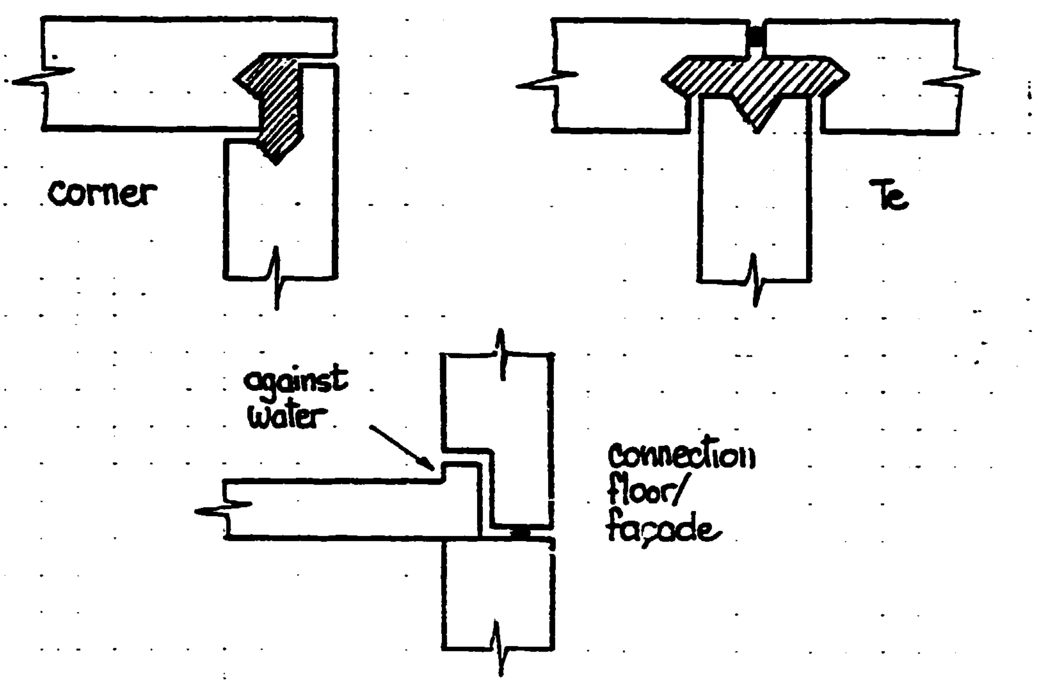
For the same service, the cost of the lodgings is somewhat higher than in conventional construction, but, according to our hosts, the quality is much greater.

The technology used allows the construction of 8 storeys, but it never exceeds 5 because of the lifts legally required over 5 storeys.

Production is on the decline because of the economic recession.

Unanimously, our hosts demand the standardization of the sizes of doors and windows.

Technological details



Thickness of all panels: 12.5cm
Thickness of partitions: 6cm

Impressions of visit

Production greatly affected by the technology of the closed system. If the transition to a production of catalogue components for an open system seems difficult, it nevertheless seems possible.

The products seen are of good quality.

The same goes for the housing built with these components.

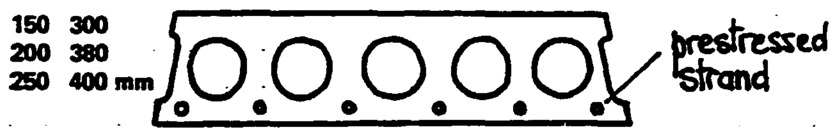
The management, young and dynamic, seems greatly motivated and is imaginative in seeking economical solutions.

The know-how of the teams for the production of components is undeniable.

Plant visited **SAMICK J/V SDN BHD**
Lot 1487 Mukim Cheras Off
56 000 KUALA LUMPUR

Persons encountered B. W. YOON Factory Manager

The plant mainly produces hollow floor slabs of pre-stressed concrete. It was recently built for a project of 2 000 lodgings. Daily production: 700m² of floors by two teams. The technology uses the DYCORE System.



thickn. 200 mm - lodgings
thickn. 300 mm - offices
thickn. 400 mm - parkings

The elements are produced on 3 beds 180 m long and 1,20 wide, in the open air, with a heating hearth for the thermal curing (heat carrier: oil). The concrete is prepared in a mixing plant with a volumetric batcher and an automatic system for water proportioning (unique in Malaysia according to our interlocutor). The cement is a normal Portland which makes the required 500 PSI (35 MPa) easy to obtain. The pre-stressing cables are Malaysian.

Other productions

- Thick pre-slabs (8 to 10 cm) in reinforced or prestressed concrete, 60cm wide, probably for parkings.

- Non bearing panels of lightweight concrete, as foam concrete, of 0.8 to 1.4 specific gravity, on which not much information was given.

Impressions of vist

It showed:

- The capacity to master an industrial production of elements of pre-stressed concrete. Technology still quite sophisticated, very far from on-site practice.
- The capacity to produce thin pre-slabs, technology which seems promising in Malaysia because of its compatibility with conventional methods.

- The possibility of producing elements for dimensionally coordinated floors with no additional investment, because all is left to do is cut the floors at the required size.

- The development of a new technology with lightweight concrete panels, technology which is still limited in industrialized countries.

- The mastering of industrial productions using the most recent methods of water batching for example.

Plant visited **SHIMIZU PERKMBA SDN BHD**
N°2 Leboh Ampany
KUALA LUMPUR

Persons encountered **RAFIQUE ABU ZARIN** Site Engineer

The contact was made during the visit of an important housing programme of City Hall, in which 20 000 lodgings were planned (reduced to 15 000 since then because of the economic recession).

The realization was started in the form of a joint venture between the public sector (City Hall) and the private sector. Essentially in low and medium cost. The selling prices of the lodgings seen are the following:

- low cost: M$ 25 000*
- low medium cost: M$ 37 000
- medium cost from M$ 48 000 (2 rooms) to M$ 64 000 (3 rooms).

The technology used by the firm visited is that of the tunnel formwork, originated in France. Developed in Malaysia in joint-venture with the Japanese. Technology typical in Europe in the 70s.

The quality of the realizations visited show the mastering of the quite delicate know-how required by this technique.

* M$ 1 = US$ 0.4 = FF 2.5 (February 1987)

Plant visited **SUN BLOCK SDN BHD**
Lot 4 Bangunan PFIZER
46 200 PETALING JAYA

Persons encountered **WINSTON K. K. ANG.** Production Manager
HUSSAINI ABDUL KARIM Operation Manager

SUN BLOCK is essentially concerned with the industrial production of hollow concrete blocks and interlocking paving blocks for road surfaces. The design of the blocks is that of the so-called "American blocks", i.e. with thick walls (≈ 25 mms) and open cells. These products generally have only 2 cells*.

The size of the blocks are typical of American blocks:

- length: 400 mm,
- height: 190 mm,
- thickness: 90 mm to 190 mm.

Also a production of concrete bricks (110 x 76 x 230 mm). For facing blocks, production of elements amongst the most recent in the USA: the split face blocks and split fluted blocks (Corduray Blocks) which seem to interest local architects.

The interlocking paving blocks have shapes known in the whole world, particularly in Australia.

The plant, covered, is organized around a German production line, ZENITH, entirely automated and operated by a programmable automaton. The installation is one year old and cost M$ 2 million (US$ 8 million). Compared to a western installation, handling is not automated and the products are left to harden in the open air, the local climate being favourable. Between the elevator for the fresh products from the press and the lowerator for the hardened products for the pallet loader, the products are left on "legged boards" handled by a fork lift. The cement used is a normal local Portland. 14.1% cement in the paving blocks give them a 54 MPa strength, which shows the high mastering of the fabrication process. For blocks, regulation requires 7 MPa, but the production generally offers 20 MPa.

According to our interlocutors, local competition essentially comes from small manual manufacturers, who maintain a low quality and contribute to the degradation of the image of concrete blocks.

* Compared to European blocks: thin walls (18 mm), bedding course, numerous cells and 50 mm long.

Impressions of visit

The plant is of a technical standard comparable to that of long-industrialized countries, be it

- the machines and equipment used: it is the same,
- automation by programmable automatons
- productivity, increased it is true, by an abundant and active workforce
- strength of the products (it would be excessive in Europe, and considered too costly in cement).

The diversity of the manufactured products show an undeniable wish to supply new products to markets not yet exploited. And the aptitude for innovation, for example in:

- the split fluted blocks,
- a system of dry laying of the blocks, the binding of the work ensured by a glass-fibre reinforced mortar coating.

From the point of view of the staff, the western visitor notes:

- the importance of the staff,
- the quality, youth and motivation of the management.

To put it in a nutshell, a genuine aptitude for adaptation.

Plant visited HUME INDUSTRIES (MALAYSIA) BERHARD
Jelan Kelang
KUALA LUMPUR

Persons encountered RICHARD W. C. NG — Production Manager
JOHNNY C. H. TAN — Technical Products Executive

The plant visited is part of a group of 9, founded in 1939 by an Australian company for the production of pipes. The salaried staff of the Concrete division of the group numbers 500 (20 engineers), of which 200 work in the Kuala Lumpur plant, the largest.

The Concrete division can manufacture all concrete products corresponding to a market demand. The plant visited showed products as diverse as:

- pre-stressed beams of large sizes for road bridges,
- pipes of all sizes and classes of strength,
- façade panels in standard concrete and GRC,
- scales of reinforced earth (Vidal Process).

The important projects are generally realized in joint-venture with other, and often foreign, compagnies. It is the case for 3 buildings much in the public eye in Kuala Lumpur: Pan Pacific, UMBC and especially DAYABUMI, symbols of Malaysia's modernity, realized with a Japanese company.

The detailed visit of the plant showed:

- Pre-stressed beams of large section (span 26.5 m, height: 1.5 m) for road bridges. Remarkable quality of the products. Quite delicate technology perfectly mastered in rather difficult conditions (lack of space). Intelligent design of the products.

- L-shaped breast walls, reinforced earth scales and concrete columns for electric lines, all of excellent making, with the characteristic finish of plants with abundant labour.

- Drainage channels, septic tanks and box-culverts, also in reinforced concrete and with an excellent finish.

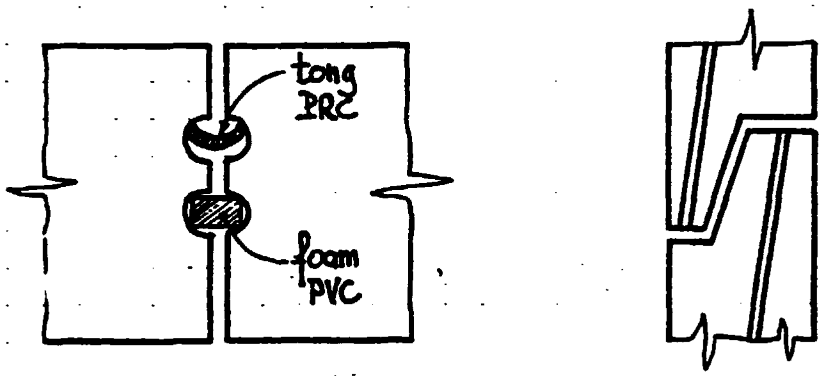
Concrete pipes of 300 mm to 2 000 mm diameter in different classes of strength and shapes of joint. At the end, a technical note was handed to us, for the sizing and the placing of the networks realized with these components. Document compiled by the firm, with all placing cases, which reveals its mastering of the great skill required by the very complex computing.

On the other hand, the centrifugal moulding technology used is rather old. It achieves good quality pipes but the rather low productivity (mean cycle of 20 mns) led to its abandon in industrialized countries because of its high labour cost. HUME preferred adding work stations to maintain an unsophisticated but reliable technology.

Also noticed: channels with elliptic reinforcement, others with PVC lining; two rather sophisticated techniques.

- Finally, façade components, the production of which the Malay Authorities seek to promote.

We therefore were able to see panels with incorporated acroterions 13.5 cm thick, the organization of the joints was the following:



Vertical joint   Horizontal joint

On the subject of the joint, our interlocutor claimed: "the technology of the joint is the manufacturer's business. The client just wants a joint that will fulfill its purpose."

The external skin of the panels was tiled, and the whole was of excellent workmanship.

We were also shown equipment for the production of GRC* components, by Spray method or Premix method. The moulds are of GRP (Glass Reinforced Polymer) and create an appearance of natural wood mith its rough patches. Another quite sophisticated technology which seems perfectly mastered.

Impressions of visit

It is the diversity of the technologies grouped in such a limited space which impresses the most the visitor: pre-stressing, GRC, piping machines, components: they are only exceptionally found in the same plant, and this emphasizes the will of the firm to open up to all interesting markets concerning concrete products.

The quality of "industrialist" is here largely claimed and demonstrated: there seems to be no special relation with a particular contractor, but a permanent possibility to found a joint-venture with a principal. Never, during our visits, has it been so clearly established that a manufacturer could live that way on an open market, without depending on a specific contractor.

The capacity of such a firm to open up to the market of dimensionally coordinated components, if the market demand should justify it, is therefore made obvious.

*Glass Reinforced Concrete, English process of reinforcement of the concrete with glass fibre resisiting to the cement paste's alkalinity.

APPENDIX B

HORIZONTAL COORDINATING OF PLANS FOR TERRACE HOUSES

Position of the problem

The division of the lots of land for the construction of terrasse houses is effected by urbanists, before the design of the lodgings.

This procedure makes all ulterior adjustment of the size of the lots impossible in order to answer the rules of dimensional coordination, which would have finally appeared too heavy, because of its strict dependence on an essentially evolving sketch.

During the transition from the imperial to the metric system, the competent authorities accepted to divide the lots with multiples of 30 cms.

The question for the designer is the following: as the coverage space is already determined, how will the rules for dimensional coordination be applied?

We shall only concern ourselves here with the façades, as coordination in the other direction does not create any particular problem in either option.

OPTION 1

1. Essential prerequisite

The width of the lots is a multiple of 30 cm.

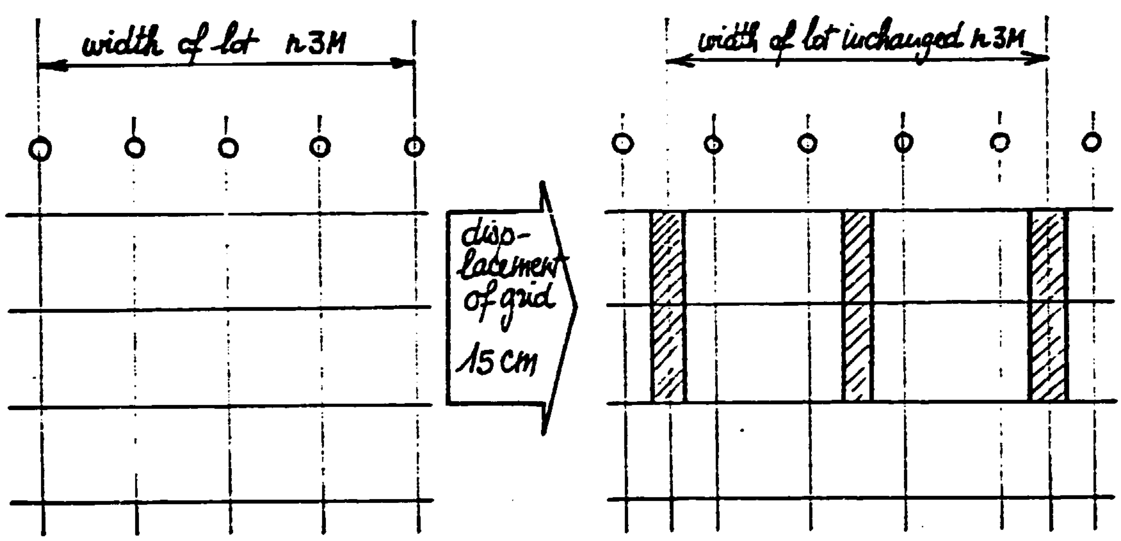
2. Lateral shifting of the grid of 3M/2 = 15 cm

3. Application of the rule of crosswalls centred between two reference planes

3.1 The thickness of the crosswalls does not effect coordination

3.2 There can be intermediate crosswalls or not.

3.3 Thin crosswalls can be assimilated to partitions



Alternative 1= displacement of grid: 15cm

4. Consequences on the sizing of the components

Consequences of option 1 in general, i.e.:

- running façades in horizontal coordination
- inserted façades not in horizontal coordination
- floors of uncoordinated length.

OPTION 2

1. Essential prerequisite

The width of the lots is a multiple of 30cm

2. Placing of crosswalls

According to the rules of horizontal dimensional coordination option 2. Two possibilities:

2.1 The sum of the crosswall thicknesses on the lot is a multiple of 30cm. The empty spaces are coordinated.

2.2 The sum of the crosswall thicknesses on the lot is not a multiple of 30 cm. Creation of a fictitious technical space which completes up to the multiple of 30cm. This technical space is situated so as to create a minimum disruption in the horizontal sizing of the components. For example:

- air gap of a double separation wall,
- particular detail of a façade.

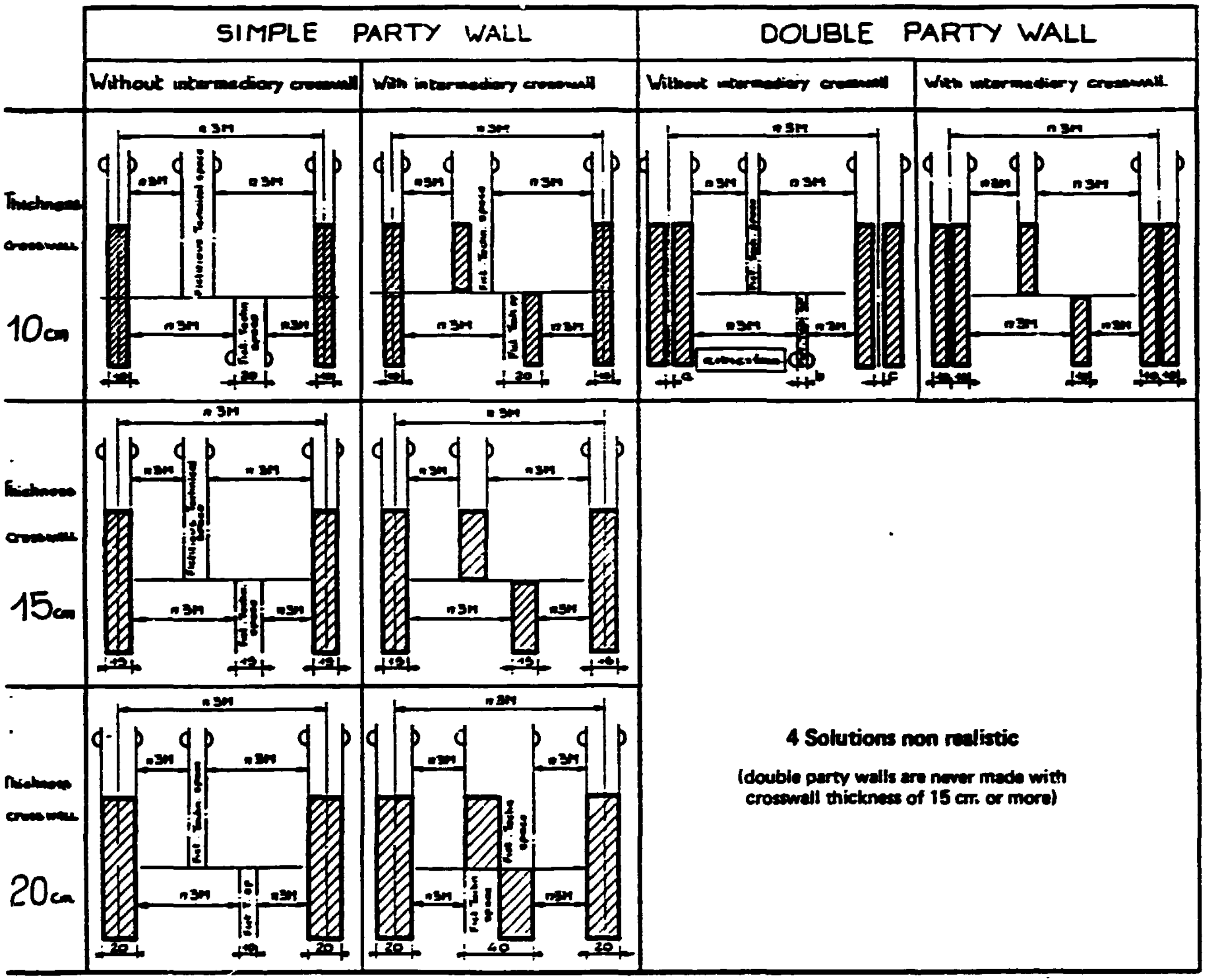
3. Consequences on the sizing of the components

In principle, those of option 2 in general, e.g.

- cladding façades not in horizontal coordination
- inserted façades horizontally coordinated,
- floors of coordinated length.

Excepting local disruption resulting from the fictitious technical space.

ALTERNATIVE 2



Option 2: table of different possible solutions for

- different wall thicknesses (10, 15 and 20cm)
- simple or double party walls
- with or without intermediary crosswall

APPENDI

Text given to participants on the of 18th February 1987 for the information day on Modular Coordination

BUILDING WITH CATALOGUE COMPONENTS OF COORDINATED SIZE

MALAYSIA

UNIDO Mission - February 1987

Marc PELCE

1. THE ACTORS TAKING PART IN THE CONSTRUCTION

The participants: Client, Designer, Contractor, Manufacturer.

To cut the costs, without losing on the quality → industrialized building.

For the Client, it means: to build rapidly, cheaper, with the same quality,

For the Contractor: to build rapidly, in a planified form, with no fear of ulterior problems.

We shall consider in turn:
- the conception of the work: (the Designer)
- the conception of the components: (the Manufacturer)

The Manufacturer's point of view:

- He wants to cut his costs in order to stay competitive, so he must:
  - increase his series,
  - simplify his production tools:
    by typifying his products and under-parts,
    with a regular production pace.
  - minimize scraps.

- He wants to increase his added value, with the finishing work integrated as far as possible.

- He wants to increase the span of his offers, therefore he must:
  - supply components that complement those offered by other manufacturers → a dimensional compatibility.

- He wants to avoid problems with the Contractor and the Client:
  - a most carefully worked out conception, to avoid having to intervene on the building site.
  - a careful placing of his production → a laying-out guide
  - a mode of production which can guarantee the (aesthetic, dimensional...) quality
  - production tolerances previously determined

The Designer's point of view

He has chosen to design with components, but:

He wants to preserve his architectural freedom
(nearly all the designs can be dimensionnally coordinated with divergences < 15cm, more often than not invisible)

He wants his design to be independent from technologies in order to put them in competition

He wants to be informed, with ease and speed, of all available offers (he is used to going through catalogues)

He wants to know at the earliest the economic impact of his architectural choices. He would like to consult catalogue tarifs

He looks for a codification of details which would enable him to concentrate on the design (analogy: drawing of screw), and more particularly on the possibility of modifying the whole project without having to do the work all over again (analogy: text processing or Multiplan)

He wants a common language with the industries that provide the components
-a "trans-product" ,"trans-technique" and "trans-technology" expression
-an independent coding of project and supplier on tolerances and compatibilities
-the existence of previous references which would guarantee the supplier's skill

He is interested in new possibilities:
special shapes, enriched claddings

He hopes for a building site devoid of surprises for he knows the cost of on-site interventions.

2. HOW CAN THESE POINTS OF VIEW BE RECONCILED?

with the help of 3 simple concepts, independent from the products and the technologies.

1)The existence of a grid:

Classical method used by the building designer, or mechanical: natural tendency to end dimensions by 0 or 5.

But: the designer wants a fine grid,
the manufacturer wants a rough grid.

Compromise generated by experience:
orthogonal reference planes
horizontal module 3M=30cm
vertical module M=10cm

But it is an ideal representation that does not take into account the physical thickness of the components. Simple and universal rules must therefore be established, to be used as reference in specific cases.

2)Rule for the design of the work

Create a maximum of interior modular spaces.

1st consequence:
in horizontal coordination, the façades are placed outside
→ creation of a modular space.

The question of the interior bearing walls then arises:
their thickness conditions the horizontal components, particularly the floor slabs.

2 alternatives, dependent on the relative costs of the components.

Alternative 1: continuous grid
The façade retains a modular dimension. But the following sequence - the floors - are layed out in a non modular space, depending on the width of the cross walls
→ the floors are not dimensionnally coordinated: an advantage for running façades.

Note: for convenience sake, cross walls are placed between 2 reference planes.

Alternative 2: discontinuous grid
un-coordinated façades are accepted in order to keep dimensionnally coordinated floors.
Consequences: advantage for the production of industrial floors.
advantage for inserted façades

Third rule: technical sizing of the component

The work must be separated in components as close as possible to those in the catalogue.

The determination of the joint technology must be left to the last possible moment.

But the work size of the component depends on the chosen alternative.

with Alternative 1:

running façades will be coordinated
inserted façades wil depend on the thickness of the cross walls (→costly adaptations)
the floors will not be coordinated (→costly adaptations)

with Alternative 2:

inserted façades will be coordinated
running façades will depend on thickness of cross walls
floors will be coordinated

Conclusions:

for a work to be done:

the grid fineness is determined
the joint size preexists

The designer can make use of the different options to search for the cheapest solution, that is the one which calls on a maximum number of catalogue components

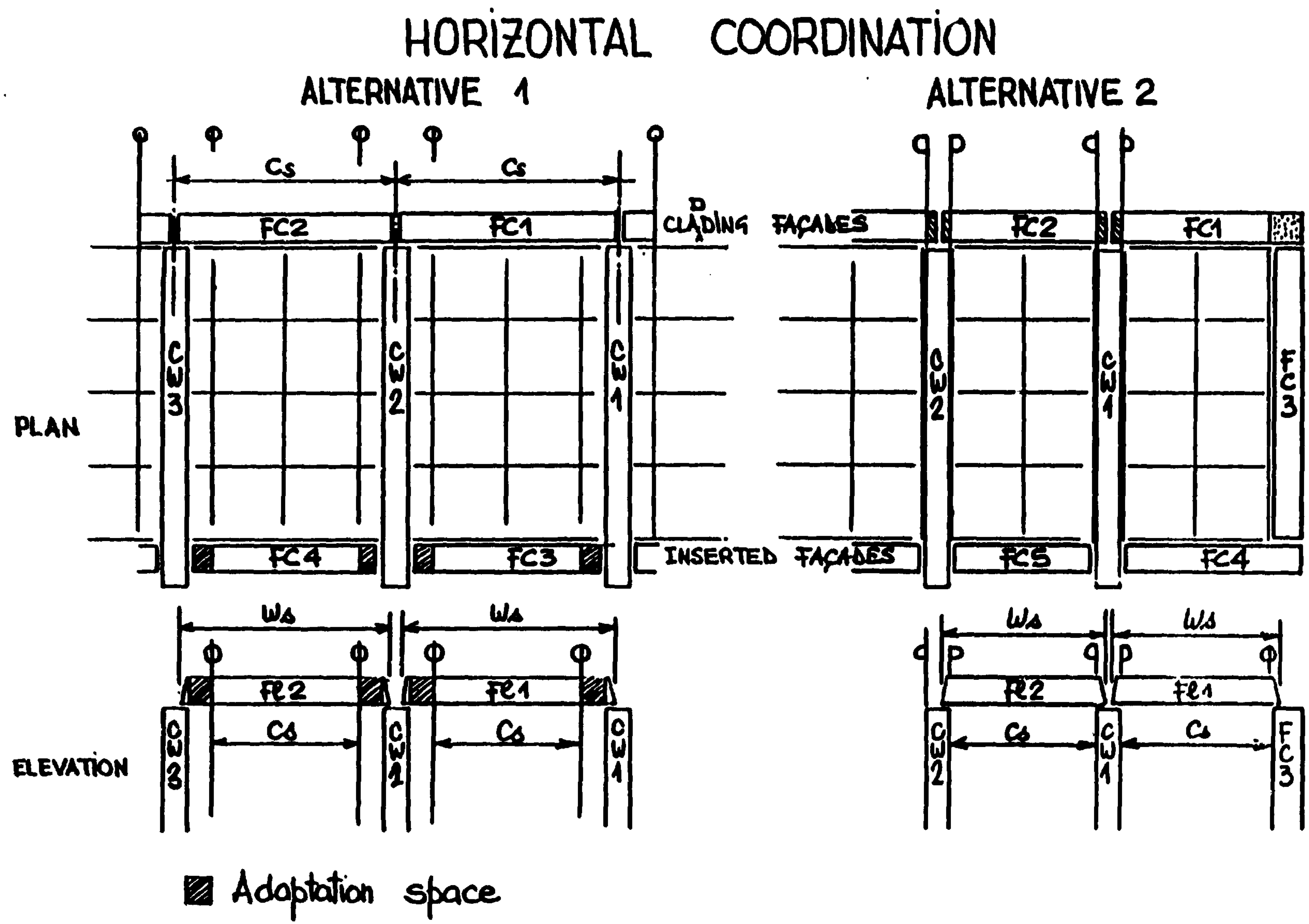


Fig. 1= Consequences of the option retained in HORIZONTAL coordination on the sizing of components

FC= Façade; CW= Crosswall; Fl= Floor; Ws: working size; Cs= Coordination size

VERTICAL COORDINATION

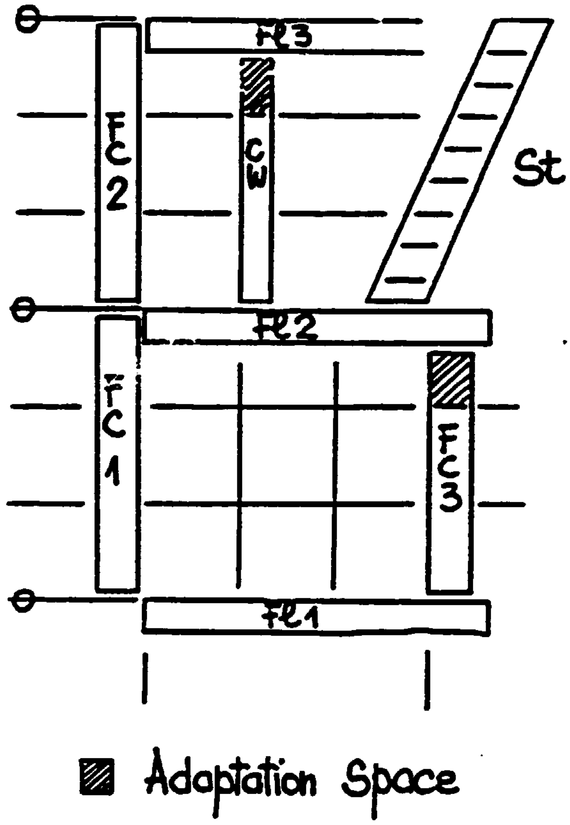


Fig.2: Consequences of the option
retained in VERTICAL coordination on the sizing of components

with FC = Façade
CW = Crosswall
Fl = Floor

3. CONSEQUENCES OF THE RULES PROPOSED BY MALAYSIA ON THE SIZING OF COMPONENTS

Envelopes:

Horizontal dimensions
Alternative 1: running façades: coordinated
inserted façades: depend on crosswall thickness
Alternative 2: running façades: depend on crosswall thickness
inserted façades: coordinated

Vertical dimensions
height of façades coordinated

Cross walls:

Horizontal dimensions
Alternative 1: length can be un-coordinated
Alternative 2: total coordination

Vertical dimensions
height of crosswalls depend on thickness of floors.

Floors:

Width: is coordinated in advance
→problems in Alternative 1
→ease in Alternative 2

Span: Alternative 1: un-coordinated
Alternative 2: coordinated

Partitions: the alternative has no impact, but the height is un-coordinated

Columns/Beams: as for crosswalls

Lightweight 3D: as for partitions

Heavy 3D: as for crosswalls

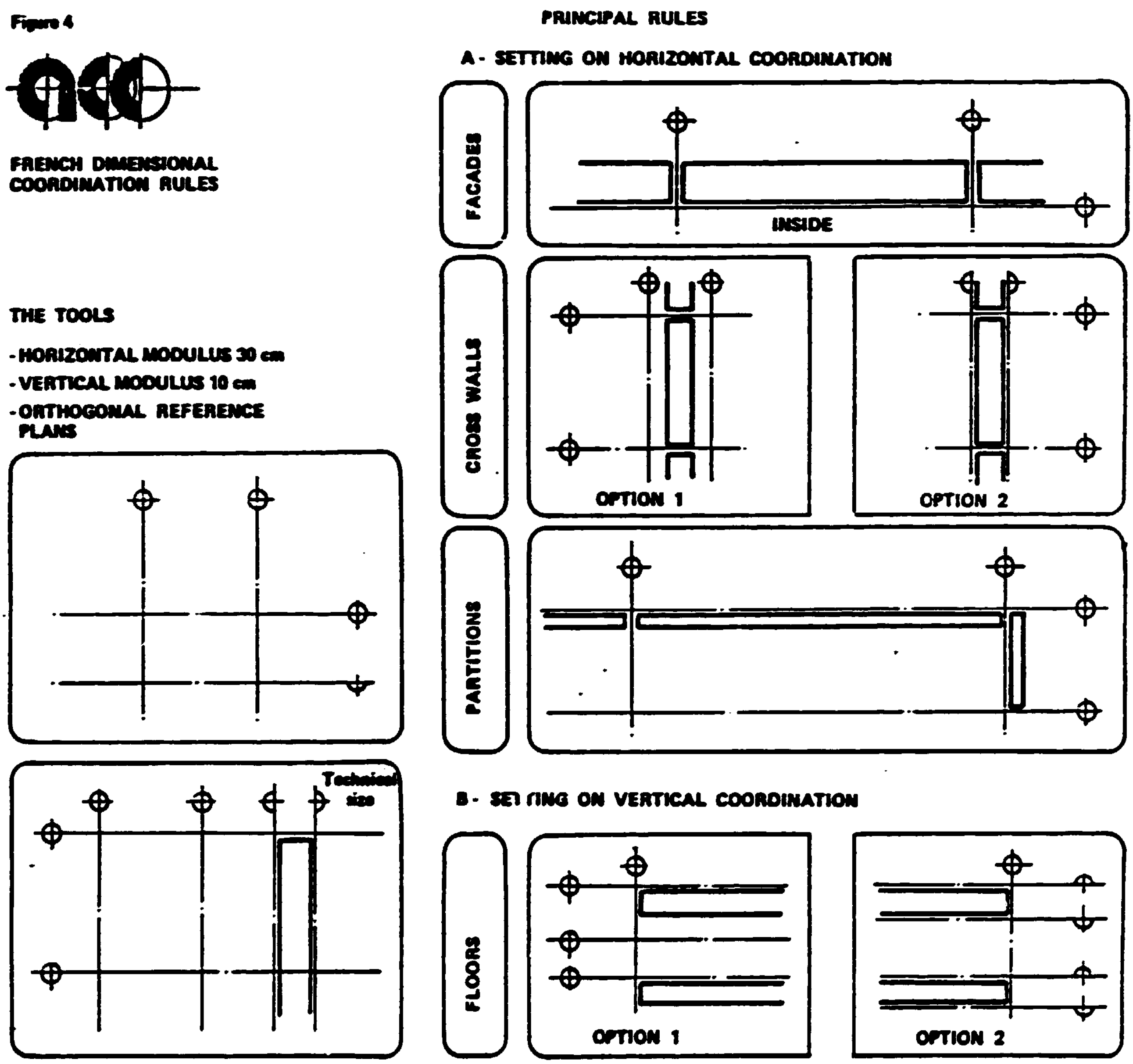
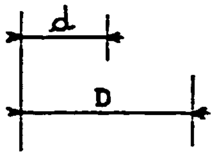


Fig.3: Main Rules of French Dimensional Coordination System

Joints and tolerances: factors to take into account

1. The joint condition

it accepts a dimensional variation contained between d and D



2. Manufacturing tolerances

Dimensional difference between true dimension and desired dimension. It depends on the tool

3. Dimensional variations of the components

thermal expansion
shrinkage / creep
mechanical behaviour (deflection)
impact of the connection

4. Placing conditions

allowances for the tracing
Placing space
allowances for the placing

These allowances depend on
the manufacturer
the placer
the joint technology

5. JOINTS AND TOLERANCE. SUCCESSIVE STEPS FOR THE SIZING OF A COMPONENT

Elements to take into account

- -role and functioning of a joint in the work
- -dimensional tolerances
- -dimension precision related to the technology

Successive steps before the detemination of the sizing

0. Determination of the components' characteristics: nature, coordination dimensions, associated components, production technology...

1. Determination of the joint and its nominal width

2. Determination of the possible variation of the joint's width

    21 Working out the dimensional differences of the joint in service, resulting from:
    - -component dimensions
    - -temperature differences
    - -shrinkage / creep
    - -role of insulating partitions
    - -impact of connections

    22 Determination of the lining's admissible % of dimensional variation

    23 Working out the minimal joint size at the time of placing.

    24 Working out the maximum joint size at the time of placing.

    25 Determination of variation range of width

3. Determination of the tolerance for the component sizes

    31 Dimensional allowances to be respected by components from:
    - -variation range of joint width
    - -tolerances generated by:
        - -work already placed
        - -tracing and assembly of these works
        - -admitted scrap ratio

4. Determination of work size, from:

the desired sizes of the components (span between joint axis - mean width of joint)
allowances for these values
wear and disturbance of the tool
frequence of repair of tool
scrap ratio admitted for components beyond tolerance

6. FUTURE PROSPECTS GENERATED BY DATA PROCESSING IN DESIGNING FOR INDUSTRIALIZED BUILDING.

To design using catalogue components implies the existence of such catalogues.
To present all the available products, it is necessary to combine:

- -all the components
- -all the sizes
- -all the joint configurations
- -all the technologies
- -all the manufacturers

This rapidly becomes physically unmanageable.

The offer of all these informations is highly simplified by data processing.

All the sub-groups pre-exist in the memory. The user has only to constitute his component from his needs.

The computer logic is unseparable from the design with catalogue components dimensionnally coordinated.

Computer tools available today include:

data bases

dimensional and technical data bases, including available sizes, accessories, minimum technical requirements

economic data bases, for the estimation of component costs and of the work executed with those components.

software

for the capture of designer's rough sketch

for coordination of a rough sketch

for testing the technical feasibility (to see if the sketch is feasible with components)

for short specs registration leading to the manufacture drawing of the component

and, furthermore,

software for the mechanical stability of the work

software for the estimation of the costs.

Every manufacturer feeds and updates his own data base for the components he offers.

Designers are thus able to consult the whole national or regional supply through the telematic network.

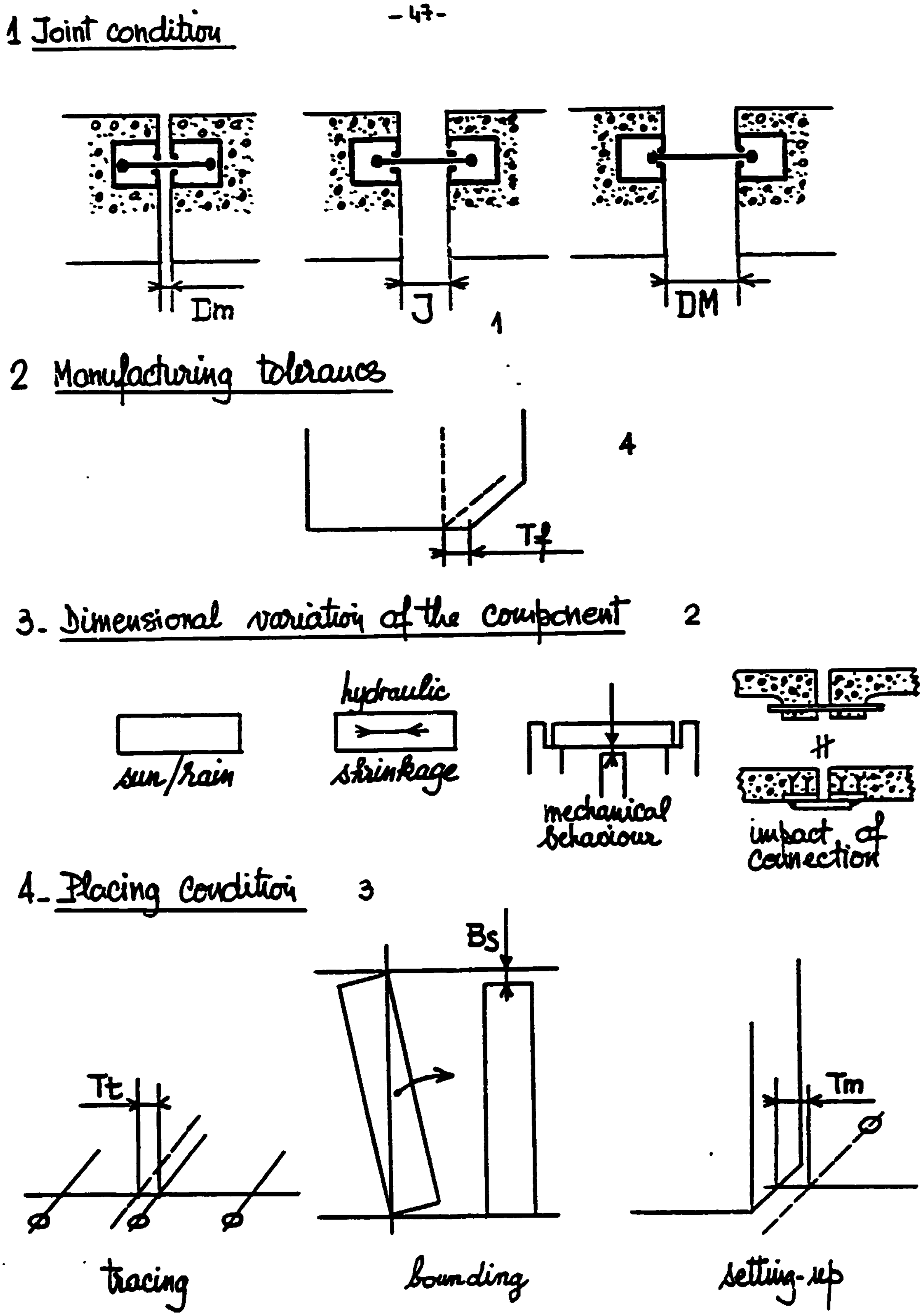


Fig. 4: The main parameters to take into account for the sizing of a component

Dm	: minimum dimension	Tf	: working tolerance
DM	: maximum dimension	Tt	: lay out tolerance
J	: joint	Bs	: bounding space
		Tm	: carrying up tolerance

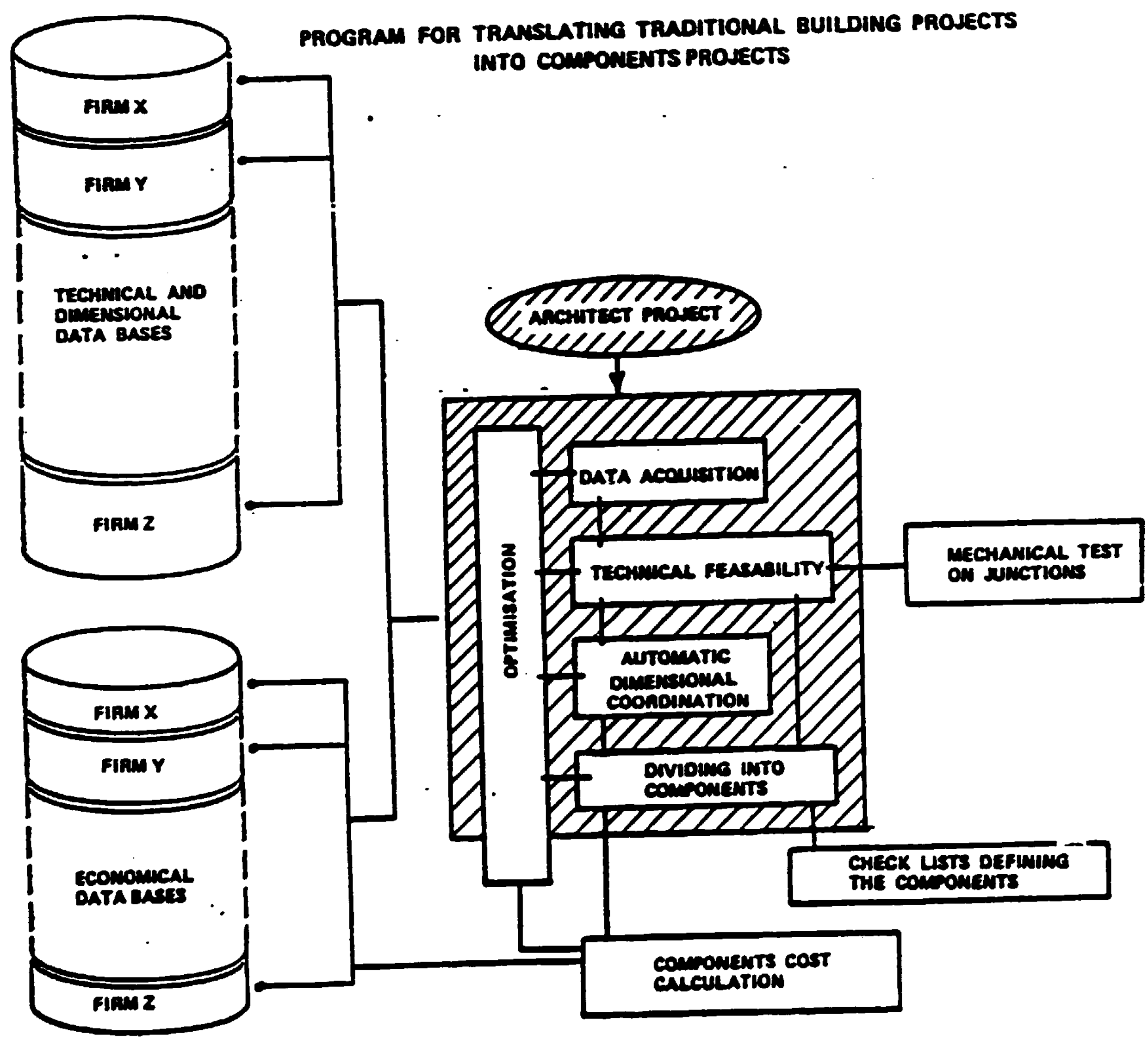


Fig.5: Program for translating traditional building projects into components projects