APPLICATION OF MATRIX ORGANIZATION APPROACH MODEL TO THE PLANNING OF BUILDING WORKS

BY

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DECLARATION

I declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.

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Date: _____

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DEPARTMENT OF BUILDING

We certify that we have read this thesis and in our opinion it confirms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Construction Management.

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DEDICATION

This Thesis is dedicated to
my late mother Mrs. B. C. ANOZIE.

ABSTRACT

This thesis presents an application of Matrix Organization Approach Model incorporating local constraints in building works.

It is proposed here to improve upon the existing construction planning methods in the country, and is the basis of the investigation carried out.

The matrix model is recommended because it clearly delves to obtain maximum technology, high productivity, maximum performance, high quality of product and high precision in construction in a cost effective manner and within time constraint; which are not obtainable using existing construction planning methods.

To achieve the above mentioned aims, the matrix organization approach model which is based on work packages with locations on the vertical axis and time phases on the horizontal axis, provides a format for the management of specialist subcontractors.

Such an approach as proposed here should increase the organizational capabilities of the country's construction constructors.

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CONTENTS

		Page
	Title	I
	Declaration	II
	Approval	III
	Dedication	IV
	Abstract	V
	Acknowledgement	VI
	Table of Contents	VII - IX
	Table of Figures	X - XII
	CHAPTER 1	
1.0	Introduction	1
1.1	Definition of topic	1
1.2	General Background of Matrix Organization	1
1.3	The need for Matrix Organization Approach Model	5
1.4	Scope and limitations	12
1.5	Basic Assumptions	13
1.6	Objectives	15
	CHAPTER 2	
2.0	Matrix Organization Approach Model	16
2.1	Heuristic concept of construction process	18
2.1.1	Linkage with the practice of quantity surveyors	22
2.2.	The formation of planning model from the translation of construction process	24
2.2.1	Resources required	24

Page

2.2.1.1 Linkage with the deficiences in CPM/PERT 27

2.2.2 End product to be constructed 31

2.2.3 Fundamental construction planning decisions 33

2.3. Construction planning and control model 34

2.3.1 Linkage of model to queuing theory in construction 38

2.3.2 Work flow study 48

2.3.3 Criticality of work flows 48

2.3.4 Flexibility attached to work flows 49

2.4 Construction planning and construction control 50

2.4.1 Linkage of model to cost control 52

2.4.2 Linkage of model to site control 53

2.5 Flexibility to create numerous construction plans from same data base 55

2.5.1 Arrangement of data into planning concept 55

2.5.2 Flexibility potential of the matrix plan 56

2.5.3 Linkage with simplicity and economic feasibility of rearrangement of input data 57

CHAPTER 3

3.0 Investigation 58

3.1 E. M. Micheletti and sons Nigeria Ltd. Enugu, and others 59

3.2 Bedero International, Abuja and others 60

3.3 Standard Construction Ltd, Kano and others 62

3.4 D. A. Nwandu & Sons Ltd. Ajaokuta and others 63

3.5 G. Cappa Ltd, Abuja and others 65

3.6 New Nigerian Construction Company Ltd, Zaria and others 68

Page

CHAPTER 4

4.0 An illustration of the application of Matrix Organization Approach Model 71

4.1 Local constraints 73

4.2 Planning Approach 74

4.2.1 Master team 74

4.2.2 Work squads 76

4.2.3 Time phases 81

4.2.4 Operation duration 81

4.3 Application of model 82

4.3.1 Horizontal Location Illustration 83

4.3.2 Vertical Location Illustration 117

CHAPTER 5

5.0 Conclusion 172

5.1 Summary 172

5.2 Recommendations for further research 174

Bibliography 175

Appendix A Traditional Classification of Subcontractors 184

" B Matrix Organization Approach classification of subcontractors 186

" C Existing Construction planning models 187

" D Questionnaires on Construction planning used in investigation 188

" E Pure Matrix Organization Approach Chart 197

TABLE OF FIGURES

			Page
Fig. 1.1	-	Matrix Organization Chart of the Aerospace Division	2
Fig. 1.2	-	Matrix Organization Approach Chart showing the relationship of master team and work squads	4
Fig. 2.1	-	Matrix Organization Approach Chart showing the inter-lock of project responsibilities and functional responsibilities by master team and work squads respectively	17
Fig. 2.2	-	Work location Analysis	
Fig. 2.2 (a)		Location: Vertical; A 4 storey building with each floor as a location and thus there are 4 locations	31
Fig. 2.2 (b)		Location: Horizontal; A 6 block units of a housing estate, with each block unit as one location, thus there are totally 6 locations.	32
Fig. 2.3	-	A matrix of locations and time phases	35
Fig. 2.4	-	Matrix model	36
Fig. 2.5	-	A queue and server relationship in a firm theatre	39
Fig. 2.6	-	A queue and server relationship of an excavation operation	40
Fig. 2.7	-	Queuing theory in construction in real world	41
Fig. 2.8	-	Work of one work squad	42
Fig. 2.9	-	Learning curve effect on work squad progress	43
Fig. 2.10	-	"Passing through" location between fast task type work flow and slow task type work flow.	46

Fig. 4.1 - A simple diagram of master team and work squads 75

Fig. 4.2 - An illustration of a pie chart showing work squads as a percentage of project cost 76

Fig. 4.3 - A plot of locations against man-hours employed (learning curve) 78

Fig. 4.4 - A plot of locations against cumulative man-hours (learning curve) 79

Fig. 4.5 - A plot of locations/volume of work against time phases (learning curve) 80

Fig. 4.6 - A three bedroom bungalow plan of one block of a housing estate used to illustrate horizontal locations 84

Fig. 4.6 - A matrix organization approach chart of master team and 11 work squads involved in the construction of 10 blocks of the housing estate 110

Fig. 4.8 - Matrix organization approach model showing the inter-relationship of work tasks, work squads, locations and time phases involved in the construction of 10 blocks of 3 bedroom bungalows of a housing estate 111

Fig. 4.9 - Continuation of fig. 4.8 114

Fig. 4.10 - Continuation of fig. 4.9 116

Fig. 4.11 - Plan of a 9-storey building with a basement underneath. This is used as an illustration of vertical locations 118

Fig. 4.12 - Elevation of a 9-storey building with a basement underneath 119

Fig. 4.13 - A matrix organization approach chart of master team and 16 work squads involved in the construction of a 9-storey building with a basement underneath 147

Fig. 4.14 - Matrix organization approach model showing the inter-relationship of work tasks, work squads, locations and time phases involved in the construction of a 9-storey building with a basement underneath 148

Fig. 4.15 - Continuation of fig. 4.14 150

Fig. 4.16 - " " fig. 4.15 152

Fig. 4.17 - " " fig. 4.16 154

Fig. 4.18 - " " fig. 4.17 156

Fig. 4.19 - " " fig. 4.18 157

Fig. 4.20 - " " fig. 4.19 158

Fig. 4.21 - " " fig. 4.20 160

Fig. 4.22 - " " fig. 4.21 162

Fig. 4.23 - " " fig. 4.22 164

Fig. 4.24 - Matrix organization approach bar chart showing the operation durations of the construction of the "Frame" of the 9-storey building 166

Fig. 4.25 - Matrix organization approach bar chart showing the operation durations of "formation works" in the 9-storey building 168

Fig. 4.26 - Matrix organization approach bar chart showing the operation durations of the "external works" of the 9-storey building 170

CHAPTER ONE

I N T R O D U C T I O N

1.1. Definition of Topic:

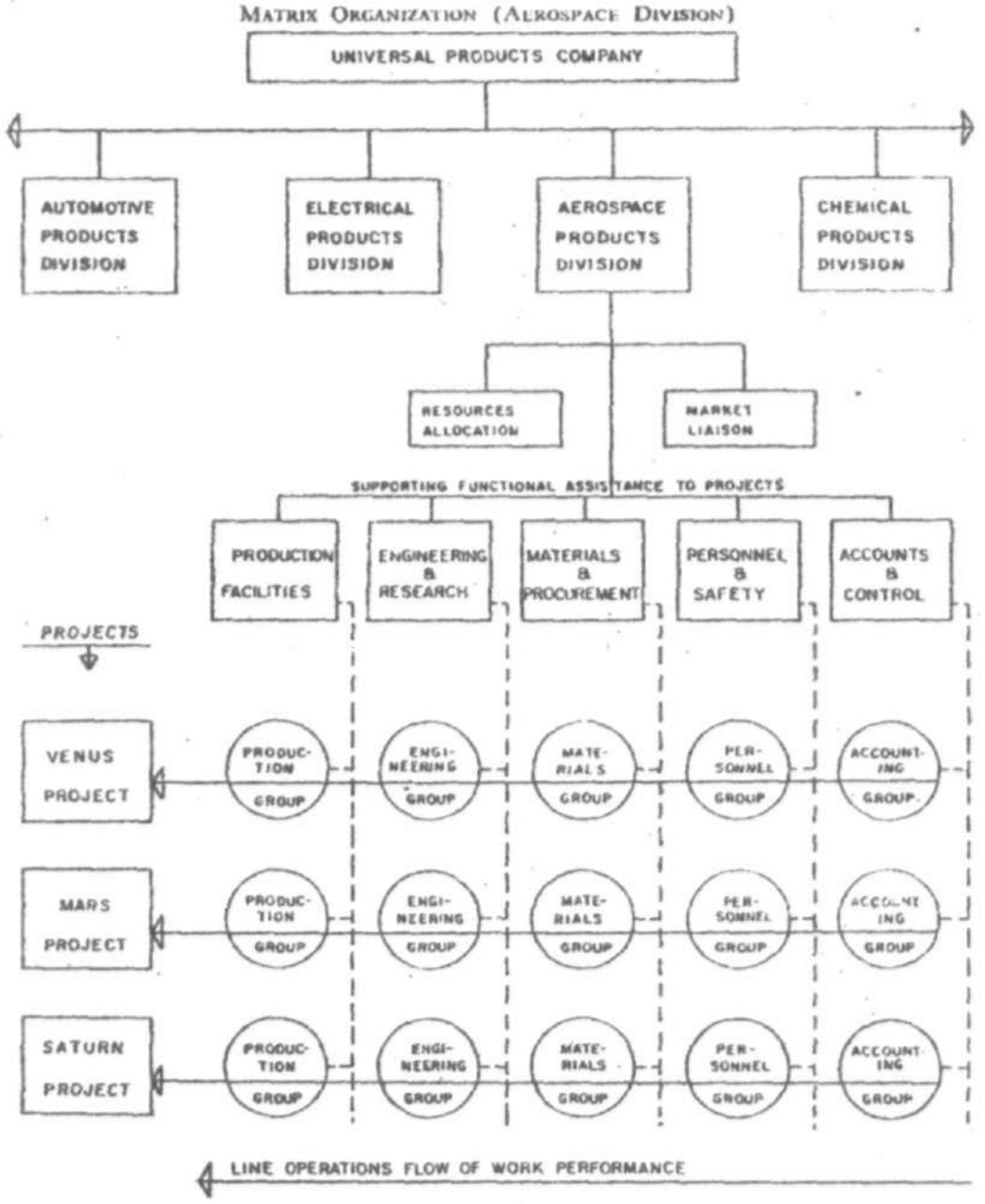
Matrix organization approach model is a concept concerned with the planning of building works derived from both the practice of construction processes and contemporary theories on the subject, based on a realistic appraisal of the local environment -- physical and social.

1.2. General Background of Matrix Organization:

Matrix organization which evolved in the development of aerospace technology is an organizational design used to establish a flexible and adaptable system of resources and procedures to achieve a series of project objectives.

EXHIBIT I

MATRIX ORGANIZATION (AEROSPACE DIVISION)



In this illustration of the aerospace division, the emphasis is on the completion of specific work projects, namely Venus Project, Mars Project and Saturn Project. Additional projects may be added as new contracts are signed by the marketing group. As projects are completed or abolished, they are deleted from the organization: It is a fluid organization.

The traditional divisional type of organization permits a flow of work to progress among autonomous functional units of specific division. A division manager is responsible for total progress of work involving the products of his division.

In a Matrix organization, the divisional manager has the same responsibility, authority, and accountability for results.

A Matrix type of organization is build around specific projects. A manager is given the authority, responsibility and accountability for the completion of the project in accordance with the time, cost, quality and quantity provisions in the project contract. The line organization under this concept operates solely in a "support relationship" to the project line organization.

The project organization draws primarily on its own internal resources; a team working under a matrix structure "borrow" resources from the functional divisions, which as stated then assume a supporting relationship. (See fig. 1.2).

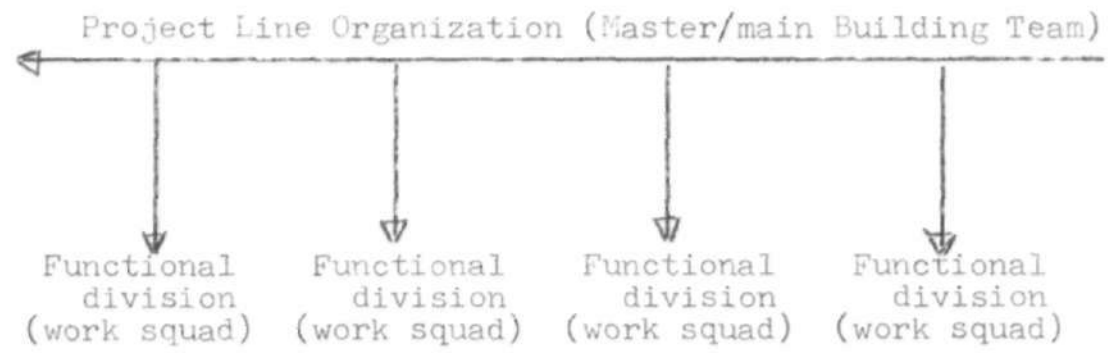


Fig. 1.2 - Matrix Organization Approach Chart showing the relationship of master team and work squads.

Management by project objectives or result is paramount to the way of thinking and working in a matrix type of organization. The group organizational personnel perform the line operational work to complete the project. The department functional personnel give support/assistance to the line projects such as policy guidance, technical advice, and administrative services. In a matrix organization chart, the line operations may be illustrated horizontally as the functional groups are aligned to achieve a specific project. The support/assistance from the functional departments appears vertically in relationship to the series of projects under-taken by the division.

The concept of matrix organization entails an organizational system designed as a "web of relationships" rather than a line and staff relationship of work performance. The web of relationships is aimed at starting and completing specific projects. An overall divisional function of resources allocation for multiple projects determines the priority of resources for specific projects and measures progress against contract requirements.

1.3. The Need for Matrix Organization Approach Model:

There is a need for this kind of research, considering the deficiencies and the failure in the application of the existing methods generally.

The best way to carry out a process must be both conceptually sound and must take recognition of the pragmatics of the situation and resources being planned. That sound concept has to be distilled from the pragmatic approaches of the many people who regularly and successfully plan, control and complete construction work. Then it has to be expressed in a comparatively simple yet useful format. In other words, an heuristic analysis of the construction process is the best starting point of the search for a sound concept of the construction process.

Division of labour brings about specialization. Matrix organization permits a higher degree of specialization for human talents, with maximum efficiency of operations. This means high quality of work-manship high precision of end product and higher productivity achieved as a result of specialization and dexterity acquired from repetition of same work type by the same functional group (work squad).

Specialization also brings about job satisfaction, security and dignity in labour. These are very much needed in this country.

Thus there is need for people to specialize in one operation or the other and work as such and be identified as or with the following:

(a) Consultants (Engineering or Management).

(b) Contractors (Builders or Engineers).

(c) [1]Specialist Sub-Contractors.

rather than be tossed up and down by business men who call themselves contractors as is the case now in this country. A break down of the main types of

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[1]Specialist subcontractor here covers any sub-contractor that is a specialist in any work task, e.g. concreting subcontractors, suspended ceiling subcontractors, etc.

sub-contractor and their principal areas of operation is given in the appendix (A and B).

Specialization also brings about increase in output (productivity) which results in the net reduction of cost. With the rising cost of building material and workmanship, there is need to encourage specialization and competition between the specialists.

Advancement and sophistication emancipates as a result of competition. This is very healthy to the construction industry generally and to developing countries especially.

To the owner, the advantage of the separate general and sub-contractor roles is efficiency by specialization which leads to lower project costs. This split also leads to industrial efficiency too.

In order to minimize the confusion in the construction process and complexity, it is advantageous that all the resource flows pass through the various locations in the same sequence. By planning this single sequence, the planner not only simplifies the plan and work, but aids in its communication to all participants in the construction process. This improve upon a major failing in C.P.M. net-works.

These participants can then more easily plan their own work and material ordering and deliveries to minimize double handling, etc. This single

sequence will also enable the project manager's or general contractor's site superintendent to build a "rhythm" of work and movements of work squads through the project.

Put simply, the typical C.P.M. approach to resources allocation is too simple for construction and tends to ignore the constraints in construction resources e.g. construction unions, non-fungible nature etc. Thus C.P.M. tends to be unsuitable to meet the needs of the construction situation. Also there is the basic incompatibility of the C.P.M. net-work with the heuristic model of the construction process.

The simplest and most appropriate way of modelling these resources requirements on a project is to consider each work squad as a continuous flow. Thus all resources are segmented into work squads, each of which is a continuous flow through the project, each tackling its same type of work in all parts of the object to be constructed.

A further need of this new model is that it enhances the required concept on construction projects so that there is no one critical path, but that all resource paths should be equally critical. A single critical path can be tolerated on a project where time

alone is being minimized, e.g., building nuclear submarines to catch up on a competitors advantage in national defence, i.e., when costs are of minimal concern. Where both direct and indirect costs are being traded off against time, it is desirable to have many paths as possible in a critical state. In construction, one is trying to minimize costs as well as time - thus the desire to adjust all resources to minimimum required cost as well as duration. Even if the planner does not consider this, the various sub-contractors will. They will operate according to these principles because in that way they can minimize their costs or best balance between minimum cost and minimum duration.

With deep reflection on existing models, another major obstacle to good construction planning and control is for many people to be involved in planning, the planning becomes an end itself. Their usual approach is that once the plan is completed they pass it on to some-one else to carry out the work. This may be acceptable of people who are involved in planning an inert end product. In such a situation the end product will be produced as planned because it is inert, static, and has no means of self-change. However, when such an approach is used to plan a process (e.g. the construction process) that is

dynamic and contains many individual resources which are controlled by a diverse group of human participants, to "plan it and pass it on" attitude is in-sufficient for successful execution of the process. Others will point out that whatever is planned for, the process will be changed by forces either outside the reach of control or within the reach of control but which are perceived as uncontrollable.

If a plan has to be continuously changed, it is highly probable that it was a poor plan in the first place or that the design or the environment has changed. Further-more, since a plan is a forecast of what will happen, the controller should motivate the resources, when to be on the job, what to do, and when to get off the job according to the plan. He exerts himself to make the reality occur according to the plan. He is the 'game coach calling the various players. He should not be the score keeper simply recording what happened on the job by "up-dating" the net-work.

The key to solving these problems is to perceive that planning should be carried out to facilitate control of the process. The objective of a plan should not be a mere hope that the process will be carried out this way or that this is one way of doing it. It should be the best way of doing it and should contain the realism of the process to be controlled.

To a large extent, the plan should contain the strength of flexibility to absorb minor time variations or location variations.

Another failure in the use of C.P.M. and PERT in construction stems from the whole net-work and mounds of computer print-out being delivered to the site. Site managers usually do not understand it and often are too busy to spend time learning about it to use it. However, using the above model of planning and controlling construction this problem can be over-come. As the matrix has a time frame on one axis, then clearly all work going on at one phase is in the same vertical column of the matrix. The quantities of each work package are known, therefore deliveries of materials and resources for that phase are known. Lead times for ordering and stimulating deliveries can be trailed back to the requisite points in time by the planners before work commences.

Control of each time phase of the project and the necessary material and resource allocations required can be developed using simple time framed net-works or bar charts understandable to site staff. Only these "short cycle schedules" are sent to the site or developed in conjunction with the site manager for the next time phase of the project within the context of the overall construction concept already planned and

the current productivity on the site. Now the site controllers only need to concentrate on marking the actual construction occur in the present phase according to its short cycle schedule.

1.4. Scope and Limitations:

Investigations concerning this research will be more on building works in this country.

However, working in an environment characterized by change, as projects are started and completed, by this method is not as comfortable and secure as performing a continuing function in a more stable, standardized work flow situation.

Matrix organization approach can be applied to the planning and control of constructions generally in any part of the world where the resources are available.

The success of this method is limited to the functionnal groups (work squads) being specialists and the master group as well.

1.5. Basic Assumptions:

It is assumed that there is no law debarring the practice of this method.

The main contractor (master team) is required to comply with the conditions of contract and will need to co-ordinate the work of all functional groups (work squads/Sub-contractors) to ensure the smooth progress of the contract. He is responsible for arranging regular site progress meetings to:

(a) Review work Completed,

(b) Discuss work under Construction,

(c) Resolve current Problems,

(d) Consider matters of immediate Importance,

(e) Advise on action taken,

(f) Discuss items likely to cause delay.

The functional groups (work squads/ subcontractors) are required to meet the conditions of sub-contract but in addition they may have design responsibilities. They must co-operate with the main contractor (master team) by attending site meetings to see how their works integrate with each other and to that of the main contractor.

From a superficial analysis, it could be expected that the diversity of self-interest that must arise from the situation where several fragmented groups go from one contract to another, and at times working on several contracts at the same time, would ensure that no contract would ever be completed. However, they are completed and a large majority within the contract period. The means to achieve this must be based on an awareness of all parties of the value of co-operation. Their interests are similar and this co-operation can only be achieved by genuine desire to appreciate the other person's point of view. The spirit of the contract should be engendered. When contractual claims are referred to, then co-operation is gone. A leader is very necessary to bring out the best qualities - the site manager must be a man of such qualities. It is accepted that good management is the ability to get things done through others and this cannot be achieved if the site manager is not a leader.

1.6. Objectives:

This research is aimed at investigating into the existing building construction planning models in the country with the objective of improving into it.

In this case propose to use matrix organization approach model because of its success in aerospace technology and indirect application in the construction industry.

This model could be adopted directly into construction planning because it complies with the nature and purpose of construction planning. More so because of its potentials.

Come up with a proposed matrix organization aporoach model suitable for construction planning in the country, taking into consideration local constraints.

CHAPTER 2

Matrix Organization Approach Model

Matrix Organization approach model is the product of the combination of the concepts of matrix organization and that of construction planning based on the heuristic analysis and pragmatics of the processes of construction.

[40]Marquis states that matrix organizations in which there is a small project team and more than half of the technical personnel remain in their functional departments, are more likely to achieve technical excellence and, at the same time, to meet cost and schedule dead lines than totally projectized organizations.

[36]Karger et al indicated that, since the Second World war, the size and complexity of engineering developmentment jobs has been increasing. The recognition of the complexity of design and the need to focus on total performance of the product rather than the components has led to the systems approach. Traditional, compartmentalized organizations and serial step approaches are no longer adequate to deal with much of modern engineering development.

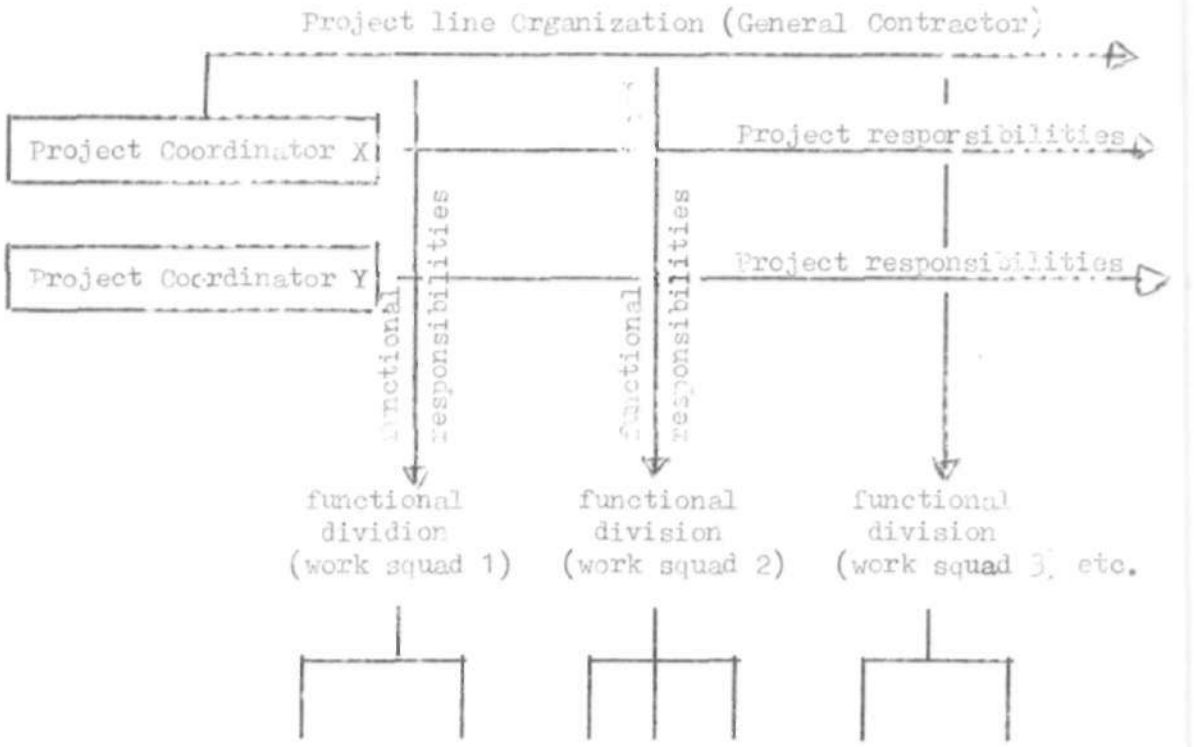

Fig. 2.1 - A Matrix Organization Approach Chart (structure)

Figure 2.1 shows the supporting relationship between project line organization and line organizations (functional divisions).

The concept of matrix organization entails an organizational system designed as a "web of relationships" rather than a line and staff relationship of work performance.

A team working under a matrix structure "borrow" resources from the functional divisions, which as stated then assume a supporting relationship.

[41]Marquis et al mentioned that, projects organized on a functional basis produce better technical results.

2.1 Heuristic Concept of Construction Process

[8]Birrell spent considerable time examining planning for construction with more than a hundred project managers, site superintendents of general constractors, and foremen of sub-contractors. He found that their thoughts on how to carry out construction processes could be paraphrased along the following lines.

Well, by looking at the drawings, I decide the sequence of the trades on a job and the route I want them to move through the job or round the site. Then I make the first work squad (functional unit) begin in a location, work space - whatever you want to call it - do their work and then move on to the next work space and work there and so on through the whole job. As soon as I can, I'll

bring in the second work squad to that first work space - may be when the first work squad is in the second work space. May be I will wait until the first work squad is in the third work space before bringing in the second work squad to the first work space so that I have a "buffer space" between them. Then I move the second work squad in the same sequence as the first work squad. Then I add more and more work squads through the same sequence. Now, once I have these flows of work squads moving through these work spaces, I push for them all to move - space to space - at about the same time, I try to build a rhythm of work and movement which all of them follow. It is like the old steam locomotives - the wheels are the work squads each progressing down the track and the piston and rods linking the wheels are my sequence of work squads and work spaces - me, the site supervisor - I am the steam governor, controlling the amount of "push" to move the pistons and rods (the plan) which make the wheels turn! Then the rhythm moves them all through the job and I have to keep it as fast as possible but not too fast or the wheels will bump into each other or fall off. You know, there is another thing, each of the work squads should be on a critical

path - you can't afford to have only one critical path -- the job goes too slow then!"

Thus, first the site supervisor decides the sequence of trade work squads, the work spaces on the job, then the "work path" for all work squads through the work spaces. The next step is for each sub-contractor to plan his own work within the sequence and time frame work of the overall plan which has been set by the general contractor. That planning will tend to begin with a consideration of resource allocation to the appropriate speed of work. Then each of the sub-contractors can establish when equipment, men, materials etc., are needed for each work space for his trade's own work flows. Of course there will be changes, adjustments, interaction to be sorted out, progress of sub-contractors to be pushed by the site supervisor, etc. but the general frame work of a construction plan is there and details can be related to that plan. Not too many details should be loaded onto the plan because if that is done, the plan will sink in details. The over-all plan should stand out by itself and show the details to be handled by each responsible participant in the construction team.

[33]Horowitz, [45]Peer, [49]Rist and [56]Ugander, indicated that, this heuristic concept of the construction process is a model that is simple, strong, realistic, optimally cheap to use, but unfortunately not written down. It is only realized by those people who are, or have been, involved in actual construction management. Senior construction practitioners who have put into writing, their thoughts on the matter and reach conclusions similar to the above paraphrase and their prestige adds weight to the concept

This concept of the construction process can handle the myriad of needs and constraints of the real environment of the construction process and the amount of management resources which would be required to consider and integrate all individual operations in the typical construction project. The numerical (and descriptive) out put from such an analysis of the actual construction process is capable of capture, optimization, and use in planning of future projects.

2.1.1 Linkage with the Practice of Quantity Surveyors

A similar historical example of an early written construction plan can be found in the evolution of the British Quantity Survey. [9]Thompson indicated that, currently, the quantity surveyor prepares a bill of quantities for bidding and as a cost data source for design cost control. However, the original Scottish quantity surveyor prepared a "schedule" of quantities which was a break-down of total quantities of each project task to quantities of work items in specific locations of the project. This "schedule" of quantities could be used for construction planning, ordering of materials, evaluating interim payments, measuring and evaluating the cost of the whole project, as well as bidding. Bidding requires only total quantities of each item, but construction planning, etc., and estimating requires the quantity of each item in various parts of the project.

Thus, that schedule of quantities was a written and quantified set of items of work in the construction process. In data processing parlance, the written and quantified description

of all the work for a project was sorted first by trade, second by type of work within the trade, third by location in the project within the type of work, and fourth by quantified items of work within each location. This written and quantified data base of the whole end product of the construction process was made up of these "mosaic chips" of construction information which could be put together in any feasible (or infeasible) construction sequence. So (before computers) that data base was mentally or manually sorted from a "mosaic picture" of the end product to another "mosaic picture" of one construction process utilizing the same set of mosaic chips of construction information. Thus [9]Birrell indicated that this document was used as a written construction control tool as well as a bidding document. Unfortunately, quantity surveyors' desire to standardize their work for the whole of the profession, and their desire to participate in the design process as a cost controller, reorientated their activities away from the complexities of the construction process. The computer and management information system concepts could enable the use of the same information in both construction process and design process.

2.2 The Formation of a Planning Model from the Translation of Construction Processes.

Construction involves: (1) The resources required to execute the work; and (2) the end product to be constructed. The work to be tackled by each type of resources or each group of resources working together will be situated in various locations of the object to be constructed.

2.2.1 Resources required: All the resources required to execute the work of the construction project are segmented by at least:

(a) The sub-contractors;

(b) the trade skills required;

(c) the labour unions involved; and

(d) the separate types of work tasks within the trade skils.

This last segmentation (i.e. "d") is usually a sub-segmentation of work in the end product to be constructed and the proceeding resource break-down in the locality of the project. These separate types of work tasks define what is required to be done by the separate types of work squads within each trade/sub-contractor's contract. Therefore they form the smallest necessary segmentation of the construction resources required to build a project.

As it is desirable that each of these work squads.will be carrying out the same type of work in all parts of the project, this fact can be used to guide in the creation of the segmentation of all the work into work flows. [19]Clough indicated that, work tasks which use the same type of materials and require the same type of labour and equipment, etc. should be kept in their individual work flows and kept separate from other work flows. As can be expected, each of the possible 50 individual subcontractors on the job is trying to maximize his profit by minimizing his own cost (usually subsequent to agreeing to a fixed price contract with the general contractor or direct with the owner), thus compounding the overall problem of control and planning. [34]Hugsted and [44]Palm indicated that, the major considerations in the sub-contracor's mind in attempting to minimize such costs of each of his work squads are:
(a) maximizing the use of the learning curve by each work squad; (b) the minimizing of starting and stopping of work squads on each flow of similar tasks; (c) the minimizing of moving work squads off and on to a project once his

trade work has begun; (d) the minimizing of cost of control supervision; and (e) placing adjacent to each other as many of his work squads as is feasible within the context of efficient construction of the whole building. The discontinuities in the activities of the workers on the project if the above principles are not followed can considerably reduce efficiency of construction process as well as unnecessarily increase the costs and the duration of the construction process.

These are major considerations which radically affect work squad efficiency and thus the cost of the work of each subcontractor which is reflected in the price of each subcontractor to the general contractor, and eventually in the cost to the building owner. Therefore, they should be considered in any construction control and planning technique. It follows that the planning technique adopted should be able to portray these principles. The typical C.P.M. net-work is not suitable for this.

2.2.1.1 Linkage with the deficiencies in C.P.M./PERT*

[52]Simon, mentioned that to produce that typical C.P.M. network, the process of planning usually follows the sequence of:

(a) List the tasks

(b) Establish the duration of each individual task on an allocation of resources required for each individual task.

(c) Develop the network logic.

(d) Find the critical path and non critical paths.

(e) On a time frame, develop resource allocation histograms for each type of resource for the whole process.

(f) Level resource allocations within acceptable or available maxima for the project.

(g) Reschedule durations of tasks to suit resource levelling.

(h) Iterate through (c) to (g) until a "satisfying" solution is achieved.

[62]Wiest, indicated that this work can be carried out by analogues (by human brain); heuristics (empirical decision rules which may or may not be pragmatic); computer resource

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*C.P.M. - Critical Path Method.

*PERT - Program Evaluation and Research Technique.

allocation package that are either mathematical programs or profile functional methods, mentioned by [5]Battersby. Examples of these more formal processes are [48]RAMPS and [63]S.P.A.R.

Moreover, all of these resource allocation and levelling processes assume a central control over the resources to be allocated and levelled. This might exist in a factory or a job shop scheduling in a factory under single ownership or single objective, but does not exist on a construction project. A general contractor may manage a construction project but he must do that through the array of subcontractors who control the resources. There may be a few or many subcontractors and each is trying to allocate and level his resources across a few or many projects simultaneously. The general contractor cannot dictate to his subcontractors the resource levels they should employ or utilize on a particular project.

This kind of action would usurp the individual entrepreneurial contractual role of both the general contractor and subcontractor. The general contractor may try to persuade the subcontractors to produce work at desired speed, but it is each

subcontractor with his perception of his overall resources and current projects, who will decide the volume of resources he allocates to each specific project. To the owner the advantage of the separate general and subcontractor roles is efficiency by specialization which leads to lower project costs for the owner. This split also leads to industrial efficiency, [7]Birrell mentioned.

Productivity in construction tends to be from a squad made up of various resources rather than individual resources working in isolation from each other. In construction, the resource allocation problem is compounded by the largely non-fungible nature of construction resources. This is a fundamental characteristic of construction resources which has been further rigidified by the construction unions.

Put simply, the typical C.P.M. approach to resource allocation is too simple for construction and tends to ignore these constraints. Also, there is the basic incompatibility of the C.P.M. network with the heuristic model of the construction process. Thus C.P.M. tends to be unsuitable to meet the needs of the construction situation. The most appropriate and simplest way of modelling these resource requirements in a project is to

consider each work squad as a continuous flow. Thus, all resources are segmented into work squads, each of which is a continuous flow through the project, each flow tackling its same type of work in all parts of the object to be constructed.

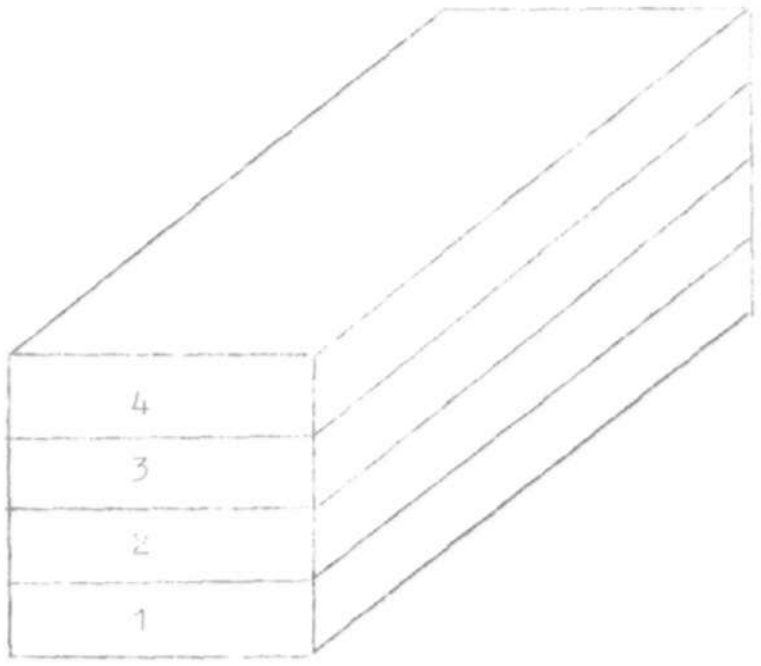
It is advantageous that all the resource flows pass through the various locations in the same sequence, in order to minimize the confusion in the construction process and complexity. By planning this sigle sequence, the planner not only simplifies the plan and work, but aids in its communication to all participants in the construction process. This improves upon another major failing in C.P.M. networks and the bar chart etc.

[8]Birrell mentioned that these participants can then more easily, plan their own work and material ordering and deliveries to minimize double handling, etc. This single sequence will also enable the project manager's or general contractor's site superintendent to build a "rhythm" of work and movements of work squads through the project. By this type of planning, he has the potential to create a work "pulse"

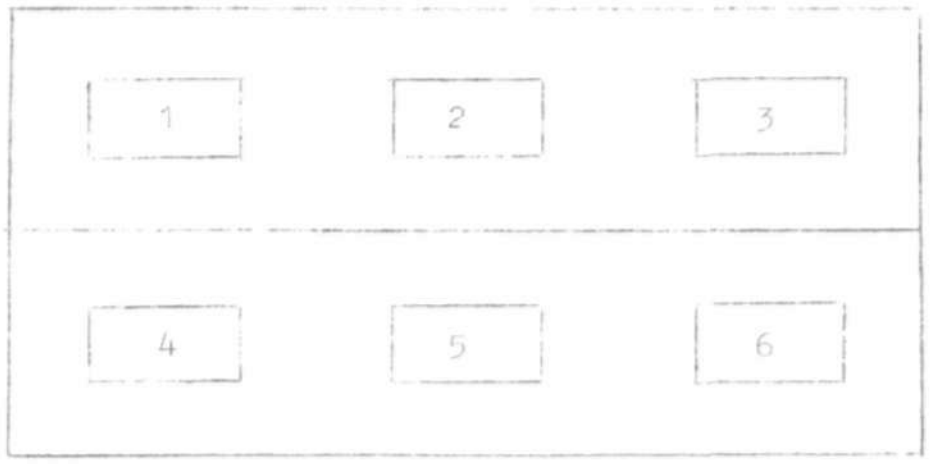
for the project which can develop its own momentum to carry the work of all contractors to its completion.

2.2.2 End Product to be constructed:

As mentioned in the foregoing, the work of each work squad will most likely be found in a number of locations in the project to be constructed (fig. 2.2).



(a) Location: vertical;
A 4 storey building with each floor as a location and thus there are 4 locations.



(b) Location: horizontal;

A 6 block units of a housing estate with each block unit as one location, thus there are totally 6 locations.

Fig. 2.2 - Work location analysis.

The vital issue in fineness of locational definition would depend on each work space having about the same volume of work for all work squads and on the complexity of the subject involved. Such choice is dependent on the size of each specific project under consideration. Big projects for instance are simple agglomerations of small projects. Thus the analytical capacity and construction knowledge

of the planner to decide on the best set of small projects within the big project to facilitate the construction process is very important.

2.2.3 Fundamental construction planning decisions:

The foregoing factors in the construction process pose the conclusion that in construction the fundamental planning decisions are not of accurate durations of specific operations, operation durations floats, individual task resource allocations, calculation of probabilities of task finishing as planned, etc. but are (a) The sequence of the object to be constructed into the most suitable "work location"; (b) the sequence in which all the work squads will pass through these locations; (c) the analysis of the required work into suitable types or groups for individual work squads in that project in that locality; and (d) the accuracy in the measurement of time for that construction project.

The planner must have fundamental knowledge of construction technology and its industrial organizations, preferably in the locality of the project, to make such decisions. If a construction planner operates regularly in one locality, he will know the local break-down or trades, etc. If he is new to the locality, he should have found out these bread-downs in his initial project appraisal to assist in estimating the cost of the project. The only variable for such a construction planner dealing with a new project is to analyze the object to be built in the previously mentioned manner.

2.3 Construction planning and control model:

Based on the construction process, the resultant model is a matrix of, on one axis, time phase and on the other axis, work locations (fig. 2.3).

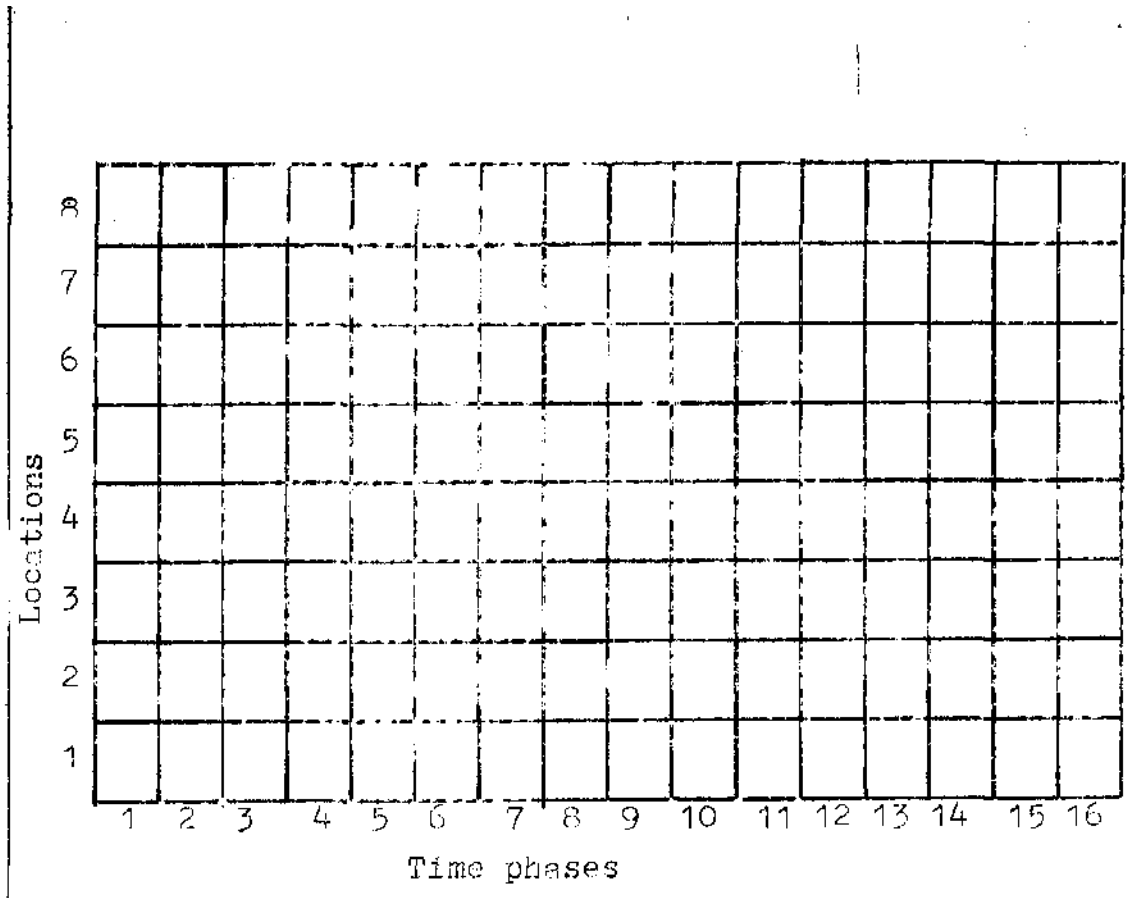


Fig. 2.3 - A matrix of locations and time phases.

The time phases for each project are of a degree of details, e.g., a half day, a day, or a week, depending on the overall duration set for the project, the complexity of work to be carried out, and its interface with deliveries of resources to the project. These time phases make up the horizontal axis of the model.

The work locations are sequenced on the vertical axis of the model in the order in which the work squads will pass through them i.e., the locational analysis of the object to be constructed. Each

matrix intersection represents a "work package", i.e., a quantity of a particular type of work at a specific location to be carried out by a specific work squad (see fig. 2.4).

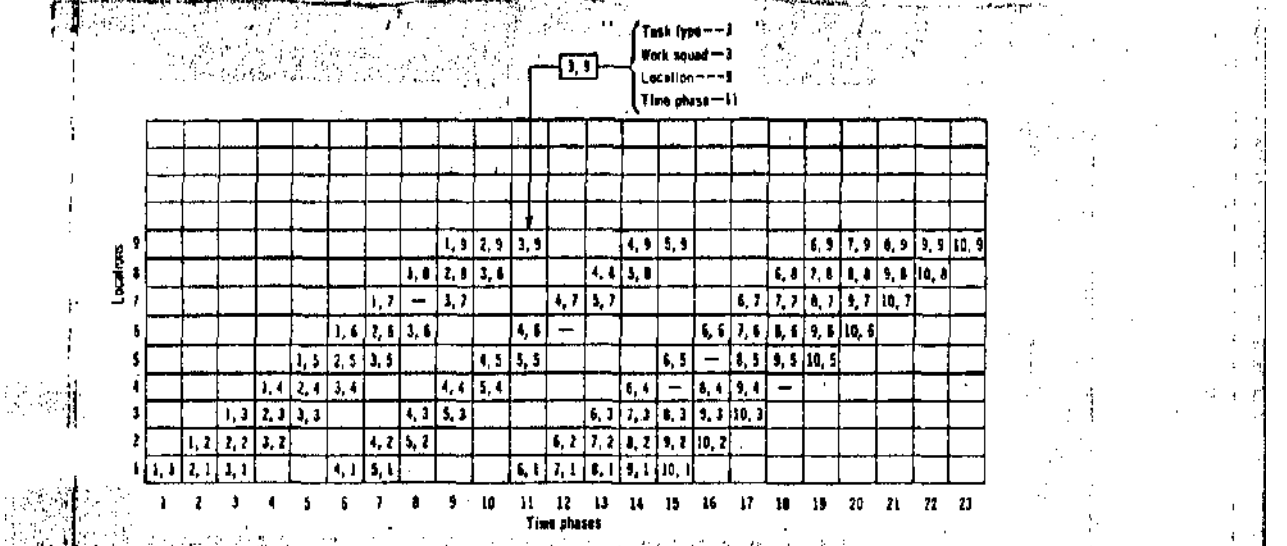


Fig. 2.4 - Matrix model.

Source: [8]Birrell G. Z., Construction planning beyond the critical path, Journal of the Construction Division, A.S.C.E., Vol. 106, No. C 03, Sept. 1980 pp 389 - 407.

Figure 2.4, shows the inter-relationship of the work squads, the different location and the different time phases. This in essence is a network analysis in construction in real world.

The actual quantity of work in each work package may vary from zero upwards depending on what work content exists in that location for that work squad. Each work squad flows through the matrix along its designated diagonal path.

Evaluating this model against descriptions of real world top quality construction planning, one finds that they are entirely compatible.

[42]O'Brien indicated that, in construction process, the work flows of different trades passing through the building are intermingled or sequenced generally on the basis of "roughing" work for all trades being carried out before finish work for all trades. These work sequencing decisions are made by the individual general contractor or construction project manager, or both, in planning the required construction process over time.

The concepts of absolute logic (i.e., columns must be built before beams) and preferential logic (e.g. floor tiles before or after ceiling tiles etc)

are major aids in deciding the sequencing of the work squad tasks. This also determines the potential freedom which the planner has to sequence the work flows. Work flows sequencing ruled by absolute logic must be adhered to, but those ruled by preferential logic give the planner the potential to improve his plan by compacting the construction work into a shorter calender duration. For example, construction efficiency of some projects has been dramatically affected by building the super-structure before excavating the ground inside the building, but this is also dependent on iteractions with weather conditions, seasonal changes, and nature of the building.

2.3.1 Linkage of model to queuing theory in construction:

Queuing theory is usually construed as representing (a) a work unit operating at the fixed location; and (b) a set of moving units serving the fixed work unit. Simple examples of these are the super-market checkout and lines or queues for tickets at a box office (see fig. 2.5).

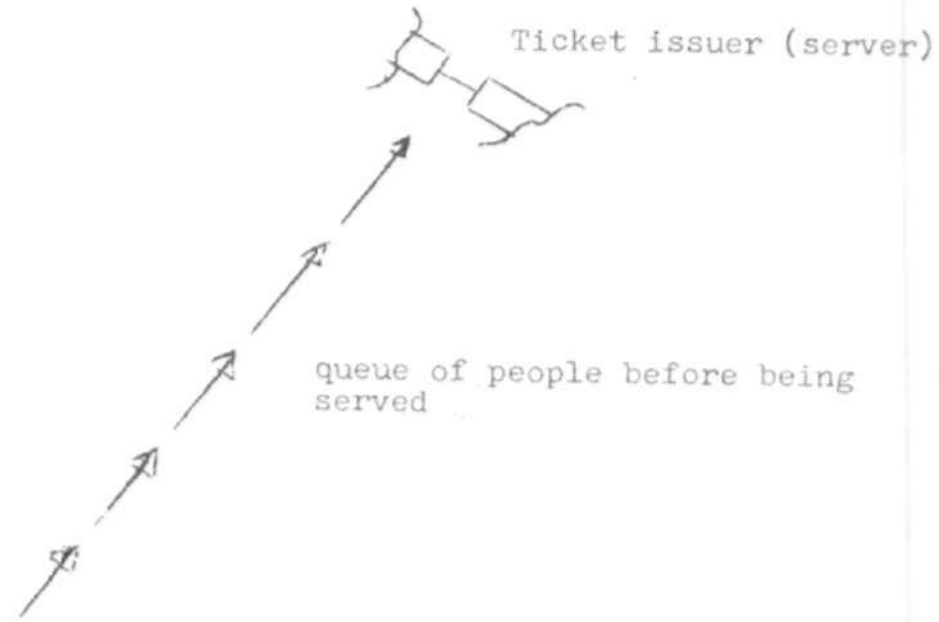


Fig. 2.5 - A queue and server relationship in a film theatre.

Figure 2.5 shows a number of people waiting in a queue to be issued with receipts into a film theatre by a ticket issuer (server).

This concept of the queuing theory is easily applicable to excavation works in construction, (see fig. 2.6).

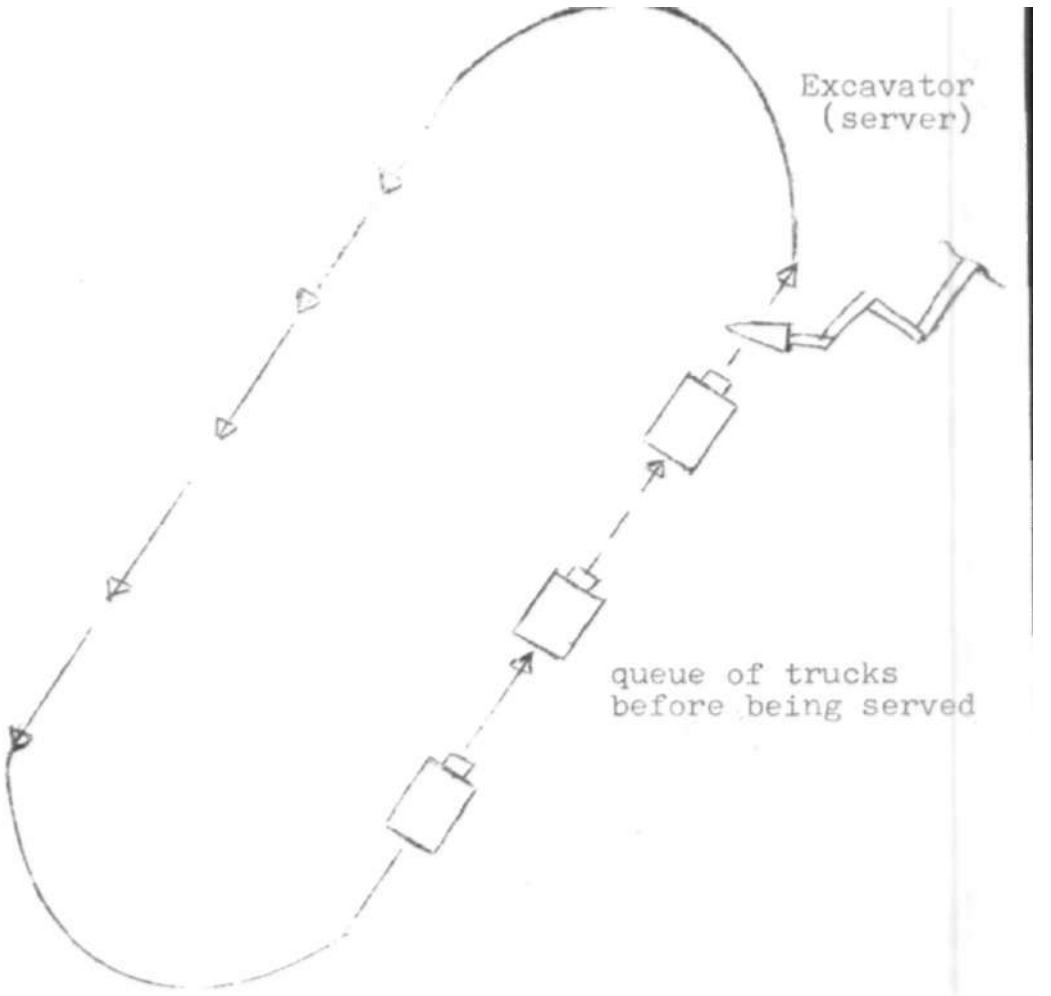


fig. 2.6 - A queue and server relations of an excavation operation.

This figure (fig. 2.6) shows a number of trucks waiting in a queue to be served by an excavator in an excavation operation. This figure also represents the traditional theoretical consideration of queuing theory in construction.

[8]Birrell indicated that, as with networks, the construction process and its sub-processes point out that the concept and use of queuing theory for construction would be the opposite to that mentioned (i.e. a single static server serving a mobile queue). The reality is that the construction process is made up of many flow lines, each of which contains a mobile work squad which moves through a set of work locations (which are the same set of work locations for all work squads). Thus, the "single server" is mobile and the "containers" in the queue are static locations in the building (see fig. 2.7).

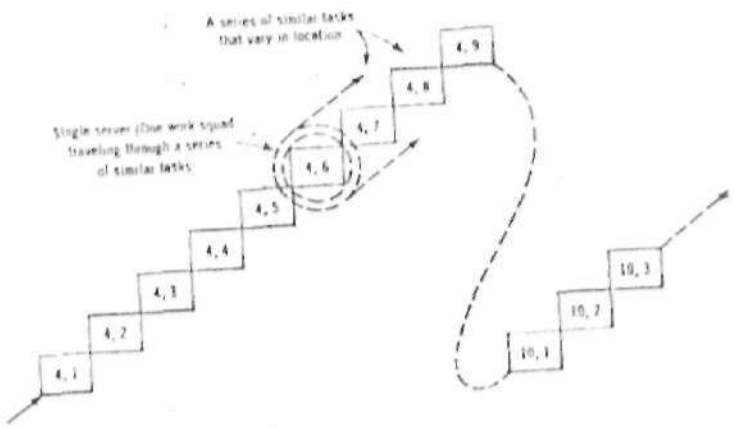


Fig. 2.7 - Queuing theory in construction in real world.

Source: [8]Birrell (see references)

This figure (fig. 2.7) shows a series of similar tasks that vary in location, done by a particular work squad (server). This entails the work squad travelling through the different locations to do the same type of work. Thus work squads 10, 9, 8, 7, 6, 5, have served the different locations ranging from 1 to 9 and work squads 4, 3, 2 and 1 are yet to perform their own services, to the different locations.

This is entirely compatible to, and in fact, enhances and strengthens the proposed network model (see fig. 2.8).

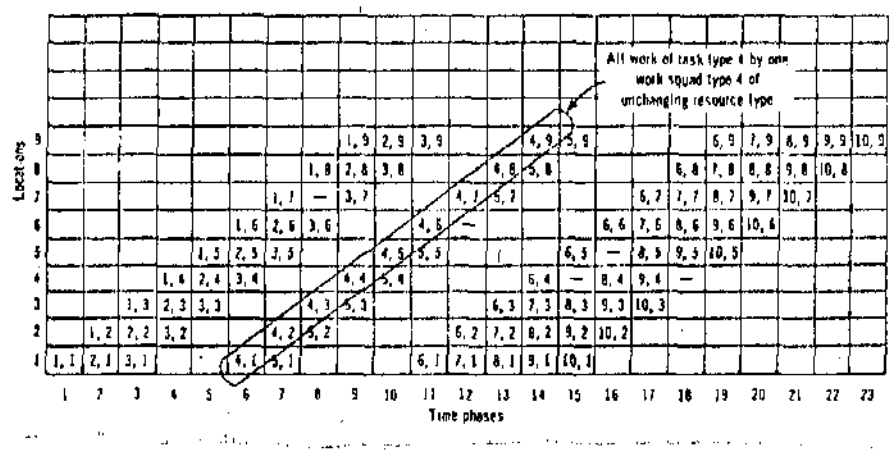


Fig. 2.8 - Work of one work squad
Source: - [8]Birrell (see references).

This figure (fig. 2.8) is a further explanation of figure 2.7. Work squad 4 is encircled in the model to further show that it travels through the locations 1 to 9 and performs the same type of operation in these locations.

[8]Birrell indicated that in planning of the construction process, care must be taken to adjust each flow line to accommodate the speeding up of the work execution of each work squad as a result of the learning curve, i.e., higher productivity is achieved if the same work squad repeatedly does the same type of work through the different locations, (see fig. 2.9).

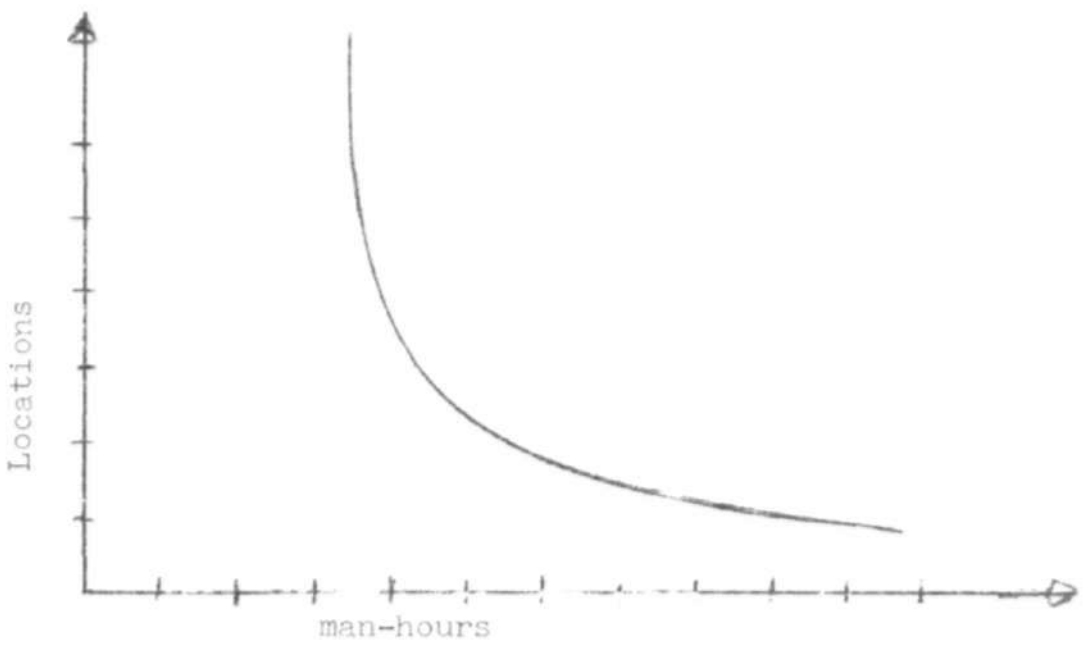


Fig. 2.9 - Learning curve effect on work squad progress.

See section 4.2.2, on page 76 for a detailed explanation of the learning curve.

More so, each flow line should be balanced against the oscillation in the smoothness of each work squad's time progress, due to the probable variance in the quantity of work in each single work package from the average quantity of work in each of all work packages of that flow line. This is executed by allowing the oscillating path of the work squad to flow with the boundaries of its path. Thus it is necessary to plan these "oscillating boundary paths" so that adjacent paths do not encroach on each other as they pass through the building. Within the minimizations of cost and duration of the overall project, and as a means to achieve this objective, the planning for control of work squads moving along their diagonal paths would be that the adjacent flow lines on the building project should have: (a) A minimum duration between the points in time of their finishing their flow line of work in the project; (b) a minimum duration for their flow line of work; (c) a minimum duration between the points in time of their starting their flow line of work subsequent to setting the proceeding requirements (a) and (b); and (d) the faster work squads be placed later in the sequence of work squads within the degree of flexibility for that choice of work sequence in each specific project.

[33]Horowitz emphasized the practical benefit of minimizing that starting delay between various work squads and placing the faster squads behind the slower squads to pressurize the earlier starting work squads to work faster. This facilitates the introduction of managerial psychology and speed competition into the planning and control of the construction process. This pushing of the actual construction according to the plan is very important to getting the project built. It can be assisted by the rhythm or pulse of the work created by the movement of work squads through the same sequence of work locations.

[11]Birrell indicated that, obviously, the queuing theory aspect of this concept is very much related to maximizing productivity of each work squad. Based on an initial presentation of this planning concept, Asley(4) has carried out simulations on resource allocation and crew balancing and found that they offer "a positive and realistic alternative to the inadequate methodologies often applied" and that they assist in testing important management decision variables before construction takes place.

[10]Birrell expressed that, allowing fast work squads to "pass through the path of slower, earlier beginning work squads should also be planned where it is possible to do so. The feasibility of passing through can be ascertained by examination of the proximity of the work of the work squads in the predefined particular work location in the building under consideration. Principles like these which deal with resolution of such conflicts are very important to both on-site construction and factory production of housing to achieve maximum speed and minimum cost (see fig. 2.10).

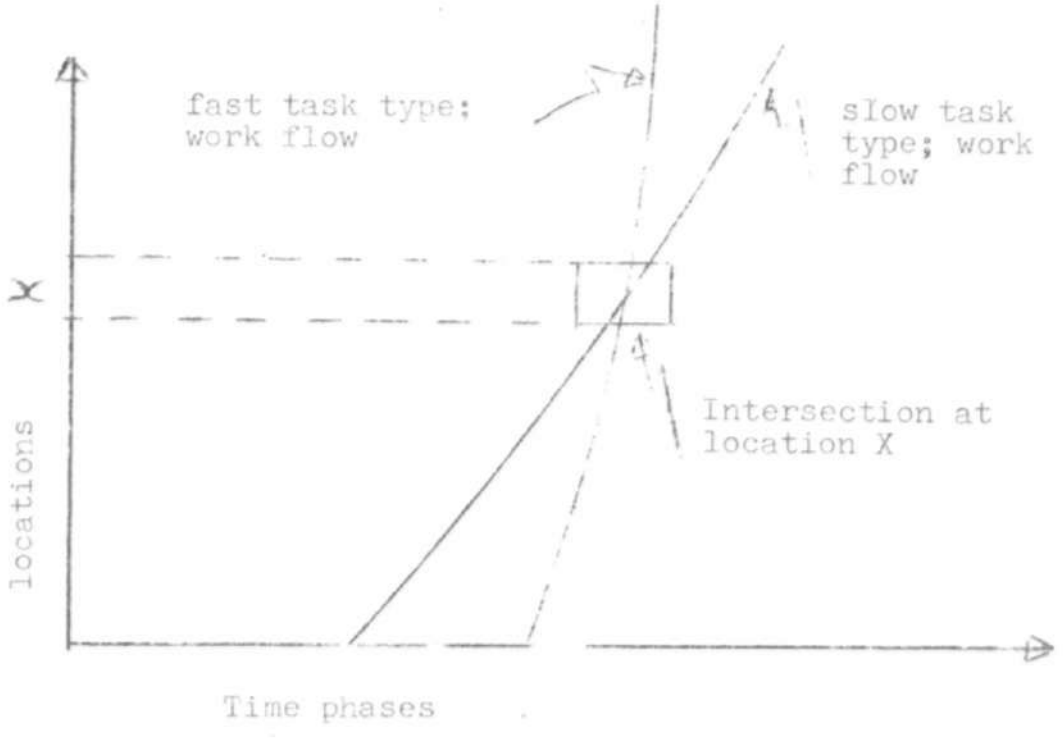


Fig. 2.10 - "passing through" location

Source: - [8]Birrell (see references)

This figure shows the intersection of work flows; fast and slow work flows.

This enables the planner to examine details of the location and to know if "passing through" is feasible or not.

Thus with this the planner will be able to ascertain the most feasible time phase of either slow or fast work squad to pass through the location under study.

Such "passing through points" alternatively can be considered as dividers of each work squad flow line into sections. Thus each section of each flow line is planned as to its location on the project construction plan by the principles previously mentioned for the adjacency of all whole flow lines as are used for the whole flow lines. It might be that such points are milestones on each flow line where adjustments in resource allocations may be made. This leaves the individual work location interfaces as minor milestone for progress checking, etc. These building construction planning and queuing theory "reality concepts" are both advantageous in more closely linking the future construction plan to the reality of construction.

2.3.2 Work Flows Study:

With this planning model it is not only easier to study a specific construction work squad activity but that study and analysis may encompass the realities in interactive activities being executed simultaneously with proceding work squad activity under study, or both. Then, causes and influences upon the efficiency of that specific activity can be studied and exprcssed objectively in time and money. This is in line to achieving high productivity and top work task performance. Also in line as an aftermath are researches into further economic reduction of overall project durations.

2.3.3 Criticality of Work Flows:

This model is of further advantage in that it enhances the required concept of construction projects so that there is no one critical path, but that all resource paths should be equally critical. A single critical path can be tolerated on a project when time alone is being minimized, i.e., when costs are of minimal concern. Where both direct and indirect costs are being traded off against time, it is desirable to have as many paths as possible in

a critical state. In construction, one is trying to minimize costs as well as time, thus the desire to adjust all resources to minimum required cost as well as duration. Even if the planner does not consider this, the various subcontractors will. They will operate according to these principle because in that way they can minimize their costs or best balance between minimum cost and minimum duration.

2.3.4 Flexibility attached to work flows:

This time phased type of model also aids the interaction between the planning and control of the construction process and the various material and resource delivery and removal of "shadow" work flows which have to be linked to the basic construction process. These activities of the shadow indirect construction tasks can be expensive. Also, because of the shadow indirect information processes of drawing approvals, and ordering dates, delivery durations can be more easily derived from this model than they are from normal C.P.M. diagram. This is due to the existence in the plan of a time frame axis broken into regular phases which can have their start data established. If all of these necessary shadow procurement and support tasks are not

integrated with the actual construction tasks, additional direct and indirect costs and time delays will occur not only to the contractors on the job, but also to the client/owner by delayed completion of the project.

2.4 Construction planning and construction control:

For many people to be involved in construction planning is a major obstacle to good construction planning and control. In this case the planning becomes an end in itself. Another failing to good construction practice is the idea of making a plan and passing it on to someone else to carry out the work. This may be acceptable of people who are involved in planning an inert end product. In such a situation, the end product will be produced as planned because it is inert, static, and has no means of self-change. However, when such an approach is used to plan a process (e.g., the construction process) that is dynamic and contains many individual resources which are controlled by a diverse group of human participants to "plan it and pass it on" attitude is insuficient for successful execution of the process. More over, others will point out that whatever is planned for, the process will be changed by forces either outside the reach of control or

within the reach of control but which are perceived as uncontrollable, indicated Bennett(6).

Another point to note is that if a plan has to be continuously changed, it is highly probable that it was a poor plan in the first place or that the design or the environment has changed. More so, since a plan is a forecast of what will happen, the controller should motivate the resources, when to be on the job, what to do, and when to get off the job according to the plan.

The solution to these problems is to perceive that planning should be carried out to facilitate control of the process. The purpose of a plan should not be a mere hope that the process will be carried out this way or that this is one way of doing it. It should be the best way of doing it and should contain the realism of the process to be controlled. The plan should contain the strength of flexibility to absorb minor time variations or location variations to a large extent.

Thus these differences in attitudes may look slight but they are the lip of the lever between successful control and completion of

the job according to plan and the failure in these respects.

2.4.1 Linkage of model to cost control:

The construction cost control processes of contractors require him to break all his work into similar pieces of work, each having its total quantity and estimated cost. Actual quantities of work put in place, and the cost of doing so at regular points in time, are compared to the estimated quantities and costs, levels of productivity established, and projections to completing forecast as a guide to controlling the actual processes of construction.

The matrix model is made up of a set of work tasks which are quantified and coded by their location on the project and by the required trade and work squad. This data base of tasks is also capable of computer sorting due to the coding derived from the stated principles. Each diagonal flow of tasks through the matrix plan by a work squad is for the same type of work, and each stage of that flow has a quantity of work defined. This is very useful as input to resource allocation on the plan.

With this work flows will be kept at the same (fastest) speed approximately.

It can now be seen that the matrix type of construction plan, when viewed along the diagonal work paths, is a comparatively simple, yet sophisticated frame work for construction cost control. Put simply, the vertical lines of the matrix are the points in time of cost control against a prequantified datum plan. The diagonal flows of the matrix plan are the rows on the conventional construction cost control documents.

Comparatively standardized throughout the construction industry is the principle of the processes of construction cost control previously described. Thus this will enable computerization and its numerous advantages to take place at the benefits of controllers.

2.4.2 Linkage of model to site control:

[8]Birrell mentioned that another failure in the use of C.P.M. and PERT in construction stems from the whole network and mounds of computer print-out being delivered to the site. Site managers usually do not understand it and

often are too busy to spend time learning about it, in order to use it. However, using the matrix model of planning and controlling construction, this problem can be over come. As the matrix has a time frame on one axis, then clearly all work going on at one phase is in the same vertical column of the matrix. The quantities of each work package are known, therefore deliveries of materials and resources for that phase are known. Lead times for ordering and stimulating deliveries can be trailed back to the requisite points in time by the planners before the commencement of work.

The control of each time phase of the project and the necessary material and recource allocations required can be developed using simple time framed networks or bar charts understandable to site staff. Only these "short cycle schedules" are sent to the site or developed in conjunction with the site managers for the next time phase of the project within the context of the overall construction concept already planned and the current productivity on the site. Thus the site controllers only need to concentrate on making

boxes on the matrix plan of the planning model. The definition of these tasks on any specific project and their quantification (if so desired) can then be carried out. This quantification can be extracted from the extimator's take off or created as part of that taking off. From the linkage between the specific tasks and their requisite quantity of work considerable benefits can be derived from the controlling of the actual construction process to that planned, its cost control, and resource delivery dates to the site.

2.5.2 Flexibility potential of the matrix plan:

With the matrix model different approaches to the achievement of the same end product can be easily followed. This is achieved by rearrangement of the work tasks on the same overall matrix frame work. Obviously, as the planner will hopefully wish to retain the benefits of the learning curve, this arrangement devolves into making decisions on the sequencing and spacing of work squad flows on the matrix as mentioned in the preceding section, 2.3.1 "Linkage of model to queuing theory in construction". Of course the use

of absolute and preferential logic in establishing the best sequence on each specific project must be considered.

2.5.3 Linkage with simplicity and economic feasibility of rearrangement of input data:

Simplicity and economic feasibility of the different rearrangements of the same work packages in different presentations must be considered. This can be met by having each work package coded by work type and location and by using a computer (or manually) to sort the one "end product" data base into whatever construction sequences desired.

This planning can be carried out by a general contractor who wishes to seek a competitive advantage by quickly and easily producing a variety of construction plans for a project before selecting the best one for each project. This could be done during estimating or before construction or at both times.

CHAPTER 3

INVESTIGATIONS

The purpose of this chapter is to find out what method of planning building works that is generally applied by Construction Firms in the country and the reasons why.

It is also concerned with why other methods are not in common use and what construction managers and planners think construction planning should be.

Details about the aims of this chapter can be seen in the questionnaires in appendix D used as the basis for the interviews. This was conducted on construction management staff (top and middle) of selected firms covering the country at large.

Building construction firms selected were those that reflected to a great extent what a professional contractor should be. This covered reputed foreign and indigenous construction firms in the country that can handle projects of 1 million Naira and above.

Also this investigation is with the aim of improving into the existing planning methods. Thus cognizance will be taken of local constraints and the general happenings in the construction industry as a whole which affects planning.

During an interview with the firm below, the following information was obtained:

3.1 Name of firm: E. N. Micheletti & Sons Nig. Ltd.

Site: New building for Cooperative Bank along Okpara-Avenue in Enugu, Anambra State.

Client: Cooperative Bank.

Cost of project: ₦500,000.

According to the Principal Accountant/Planner, this firm applies the bar chart method in their projects. It also controls the use of labour as a complimentary method to the bar chart method. Construction planning is seen by the Respondent as based on experience and an adoptation of a practical approach, derived from trial and error (which could be expensive).

This firm does not give room for researches and sees new innovations in planning as theoritical. Sub-contractors are used by this firm to a great advantage and they are seen as essential to the achievement of high quality products.

Nominated sub-contractors are seen as slightly difficult to control, due to their direct link with the client.

Analysis

In this case, matrix organization approach method will easily be applicable, since the use of sub-contractors directly under the general contractor is practised. Matrix organization approach will then go a long way to replace the conservative attitudes of these firms, with new and economical techniques which will come as inevitable. Also to be benefitted are the numerous advantages and potentials of this method, like the encouragement of specialist subcontractors, the achievement of high quality products etc.

3.2 Name of firm: Bedero International, Abuja.

Site: Sheraton Hotel Abuja.

Client: Federal Government.

Cost of project: Over ₦100,000.

The Project Manager disclosed that the bar chart method is used by this firm and this is because of its simplicity and practicality. The bar chart method is also regarded as very cheap to use by this firm. Mention was made, of site staff understanding it easily too.

Selected subcontractors are used and are seen as benefitial.

Nominated subcontractors are not used by this firm.

The productivity of local labour was classed as average by this firm also.

The same views were aimed by the following firms:

Dave Nigeria Ltd., Abuja;
Gaamstac Engineering Ltd., Abuja;
Niccolo Company Ltd., Abuja and
Sisk Nigeria Ltd., Kaduna.

These firms also high-lighted the need for proper supervision of the subcontractors to get the best out of them.

They also stressed the need for researches to encourage specialization and industrialization.

These firms are also well organised and have projects over 1 million Naira.

The country was seen by these firms as full of potentials, and if strategies were directed in the right direction, will develop very fast; technologically and otherwise (construction wise).

Analysis

These firms were indirectly preaching the use of matrix organization approach method, from the comments and problems high-lighted.

3.3 Name of firm: Standard Construction Ltd., Kano

Site: Bayero University, Kano

Cost of project: ₦500,000

The Contract Manager of this firm also uses the bar chart method for reasons connected with its simplicity and practicability.

Subcontractors are also used by this firm and seen as competent. Also compliments were passed on some subcontractors as not being organized and at times unrealistic.

Local labour was criticised by this firm as manageable.

The respondent mentioned that the company spent a lot of time coaching and training people and lost them there after. This, he felt, was a big problem to them.

The use of computers was also acknowledged.

Nominated subcontractors were passed as okay, but emphasises were laid on the use of selected sub-contractors that are directly under the general contractor.

The respondent also emphasised the need to follow specifications precisely in constructions.

The same comments were passed by the following firms:

Luna Industrial Enterprises, Kano;

Cubits Nigeria Ltd., Kaduna and

Conital Construction Company, Kaduna.

In addition, these firms advised the adoption of a practical approach to planning. Flexibility in planning was also stressed.

The need for proper supervision and establishment of accurate activity duration were emphasised, too.

Analysis

Matrix Organization method again is indirectly preached by these firms. Specialist subcontractors will be encouraged the more. Again this will have its own multiplier effect to the construction industry as a whole.

3.4 Name of firm: D. A. Nwandu & Sons Ltd., Ajaokuta.

Site: 500 housing units in Ajaokuta.

Cost of project: ₦100,000

The project Co-ordinator of this firm applies the bar chart method in planning and controlling their projects. He also sees it as best because of the situation now in the country. Mention was made of

its simplicity and practicality to the essence of construction planning.

The respondent has it that the bar chart method gives a picture of what is to be done but doesn't tell all. He sees it also as very flexible.

Both nominated and selected subcontractors are in existence in the site. The respondent acknowledged the usefulness of selected subcontractor and suggested that they should be encouraged in this country.

The productivity of the local labour was regarded as very low by the respondent. He also said that it constituted a problem to timely completion of operations.

J. Nwankwu and Brothers Ltd, Enugu, shared the same views with the previously mentioned firm.

High-lighted by the respondent of J. Nwankwu and Brothers Ltd., was the need to consider cash flows and resources required for project execution. He advised the use of the line of balance method for repetitive works.

Analysis

The application of the matrix organization approach method should be considered as second to none solution to the problems and comments made by these firms. This

is because the model is based on the management of specialist subcontractors who constitute work flows. They say that division of labour brings about specialization and so is it with this model.

3.5 Name of firm: G. Cappa Ltd., Abuja.

Site: Presidential Complex, Abuja.

Client: Federal Government.

Cost of project: ₦500,00.

The Project Manager reiterated that the bar chart method and the control of the use of labour approach are employed by this firm. This method was regarded by this firm as best for the country because of its practicability and simplicity. Mention was also made of site staff understanding it easily.

Subcontractors were highly recommended by this firm and are also being used by it.

The productivity of the local labour was seen as satisfactory. Suggestions were also made in this direction as to the improvement of skilled labour by the establishment of large training centres by government or private organizations.

The same views were shared by the following firms:-

S.A.E. System Builders, Abuja;

A. G. Ferrero & Co. Ltd., Kaduna;

B. Stabilini & Co. Ltd, Zaria and

E. d'aberto & Giampaoli Ltd, Zaria.

In addition the following suggestions were made: That planning should be done based on practical considerations. That for good workmanship, there should be available good technicians and skilled labour. That a good model should be that, with which operations can easily be visualized, enables control of progress and inexpensive to apply.

Construction planning and methods was seen as lagging behind that obtainable in European countries. Mention was made in this regard of specialist firms not being obviously available to provide good sand, stone, concrete, form work etc. Rapid drift towards this direction was also foreseen.

Furthermore "Kyauro Construction, Kano" suggested that the contractor should be the main person in the execution of a project. This it claimed will eradicate delays and some other problems in construction.

Also this firm has it, that the contractor should be the person to go to the Architect for designs and see the respective consultants for the project on the client's behalf. This was regarded as a way for the contractor to picture everything from the on-set.

Furthermore, suggested was consortiums comprising: Architects, Builders, Quantity Surveyors, Electrical Engineers, Mechanical Engineers and Structural Engineers.

"Arewa Construction" high-lighted in addition, the need for efficient and effective supervision on construction sites.

Mentioned was also the need for deep programming in order to enable contractors nail consultants e.g. on difference in cost due to variation and fluctuations etc, and precise planning.

Analysis

From all the problems and suggestions made by these firms, it can be seen that matrix organization approach method is the method that will best suit the conditions high-lighted. This is because of its advantages and potentials in the directions high-lighted e.g. it reduces project costs, encourages specialization etc.

3.6 Name of firm: New Nigerian Construction Company Ltd. Zaria.

Site: Ahmadu Bello Teaching Hospital, Zaria.

Client: Federal Government.

Cost of project: ₦1,000,000

The Project Manager of this firm applies the Critical Path Method in planning and controlling his projects. This is because he regards this method as the most precise and brings to notice, problems in time, so that action can be taken. The respondent mentioned that C.P.M. is a logical sequence planning method and he considers it the best method.

Project planning is done by the respondent and their planning engineer. From this plan, instructions are passed to the executors (i.e. site foremen).

The respondent indicated that, though the C.P.M. is an intricate method, depending on the details, it can be used for whatever planning that is wanted. He sees an overall C.P.M. as very essential.

The respondent felt that C.P.M. was not widely used in the country because people were not yet convinced.

The productivity of the local labour was seen as average by this firm.

Subcontractors are also being used in a little scale and are also acknowledged.

Finally the respondent stressed that in "planning you get out what you put".

Conthiu Caro and Company Ltd., Abuja, was of the same views with the previously mentioned firm but used the bar chart method in their short-term planning. It also warned that the C.P.M. can only be applicable where everything works perfectly well e.g. in a factory. In this regard it suggested that the use of C.P.M. is not very possible in the country.

Computer application was also suggested by this firm as a means to thorough planning.

Analysis

Whether C.P.M. or Bar Chart etc or both, the application of the traditional organization structure which is common for these methods, is in itself insufficient to meet up with the demands of construction today. By this it means that both vertical and horizontal responsibilities are required of any structure that will enable high products and complex cases. This is not the case with the traditional structure which has vertical responsibility line-up.

The matrix structure is the most suitable structure, with vertical and horizontal line of responsibilities, that can meet up with the challenges of construction of the present day. Thus the matrix organization approach model suits the demands of precise and logical construction planning of the present day.

CHAPTER 4

An illustration of the application of Proposed Matrix Organization Model incorporating local constraints in construction.

This new model is compatible with the heuristic analysis of the construction process and satisfies the deficiencies in existing methods. Also it is very much in order with the pragmatics of the situation in Nigeria.

Construction involves the following:

(a) The resources required to execute the work and

(b) the end product to be constructed.

The resources required, will be taken care of by the combined effort of the client, main contractor (master team) and work squads (sub-contractors).

The client should be ready to pay promptly for goods and services rendered.

The work to be tackled by each work squad or group of work squads working together will be situated in various locations (Horzontal or Vertical) of the object to be constructed.

[8]Birrell indicated that with this new model, first the site supervisor decides the sequence of trade work squads, the work spaces on the job, then

the "work path" for all work squads through the work spaces (locations). The next step is for each sub-contractor to plan his own work within the sequence and time frame-work of the overall plan which has been set by the general contractor. That planning will tend to begin with a consideration of resource allocation to the appropriate speed of work. Then each of the subcontractors[2] can establish when equipment, men, material, etc. are needed for each work space for his trade's own work flow. Of course there will be changes, adjustments, interaction to be sorted out, progress of sub-contractors to be pushed by the site supervisor, etc., but the general frame-work of a construction plan is there and details can be related to that plan. Not too many details should be loaded on to the plan because if that is done the plan will sink in details. The overall plan should stand out by itself and show the details to be handled by each responsible participant in the construction team.

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[2]These subcontractors must be specialist in the work tasks undertaken. Be it concreting, steel fixing etc.

4.1 Local Constraints:

Some of the local constraints that have acted directly or indirectly as a handicap to the development of the construction industry as a whole are the following:

(a) Lack of certain building materials (e.g. aluminium etc)

(b) High cost/inadequate supply of available building materials (e.g. steel, cement etc.)

(c) Difficulty in raising funds for construction.

(d) Inconsistent supply/lack of power supply in most areas of the country.

(e) Inconsistent supply/lack of water supply in most areas of the country.

(f) Slow rate of expansion of the economy.

(g) High cost of transportation

(h) Poor transport facilities

(i) Geographical immobility of labour.

(j) Inadequate/poor housing delivery system

(k) High cost of living generally.

(l) Government policy/lack of adequate planning machinery by government (e.g. high import duties etc).

(m) Shortage of manpower generally, (e.g. skilled labour etc.).

4.2 Planning Approach:

The use of matrix organization approach model is aimed at obtaining maximum technology, high productivity, maximum performance, high quality of product and high precision in construction in a cost effective manner and within time constraint.

This is to be achieved through the intercourse of the master team, work squads, location and time phases.

To be incorporated are the local constraints and the results of the investigation conducted.

4.2.1 Master team (General Contractor):

The responsibilities of this team depends on the type of contract concerned.

Here this team will co-ordinate and supervise the work squads. It will be solely responsible for the physical production of the whole building.

It will also be directly or indirectly responsible for the payments of the work squads when due. This again depends on the type of contract and agreements made.

Provision of materials and equipments will be worked out with the respective work squads and agreed upon.

Accommodation for the storage of materials will also be provided for the work squads on agreement.

Finally this team is the overall manager of the project. It is its exclusive responsibility to lead the various work squads towards the successful achievement of the target.

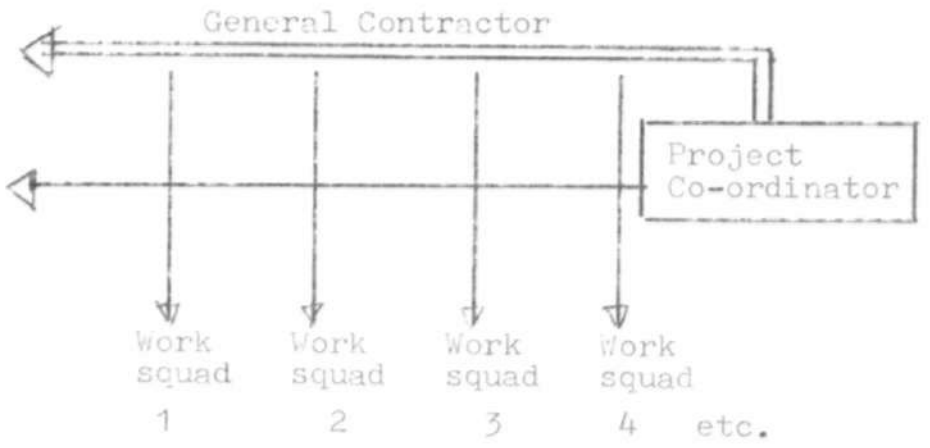


Fig. 4.1

Figure 4.1 is a simple picture of the relationship between the master team and the work squads which are regarded as functional units.

A pie chart of work squads as a percentage of project cost will give a pictoral view of the major components of cost to the master team. This will enable cost analysis, e.g.

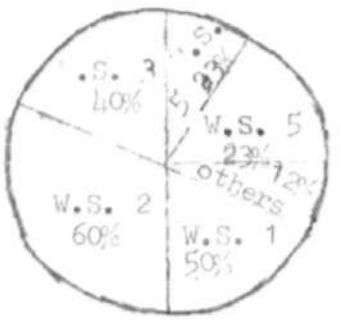


fig. 4.2 - An illustration of a pie chart showing work squads as a percentage of project cost.

LEGEND: W.S. - Work Squad

In figure 4.2 there are only 5 work squads and they constitute a total of 88% of overall project cost in this example. Other costs include master team payments and profit, and this constitutes 12% of overall project cost.

4.2.2 Work Squads:

These are specialist independent sub-contractors that are regarded as functional units in matrix organization approach model.

In order to enable easy understanding of model and for simplicity sake, different letters - a, b, c, d etc. will be used to denote repetition of a particular work squad in the same location at different time phases. The work squad may be doing the same type of task or something very similar at the different time phases in the same location.

The lettering is with the view of reminding the user or reader of the model that a work squad will repeat say thrice, in the case of a, b, c, in a particular location or that there is no repetition at all in the case of no letter i.e. no a or a, b, etc. For example "4^a, 4^b," means that the work squad 4 will repeat itself twice on the same location. But in the case of just "4", this means that the work squad 4 will occur once and thus there is no need to look across that particular location to see if there is another work squad 4.

Higher productivity is achieved if the same work squad repeatedly does the same type of work in different locations. Thus a learning curve results if a plot of the different locations is made against inputs or cumulative inputs, (say

in man-hours for instance). Alternatively a plot of locations/volume of work against time phases could oe made in the case of a continuous operation. For example:

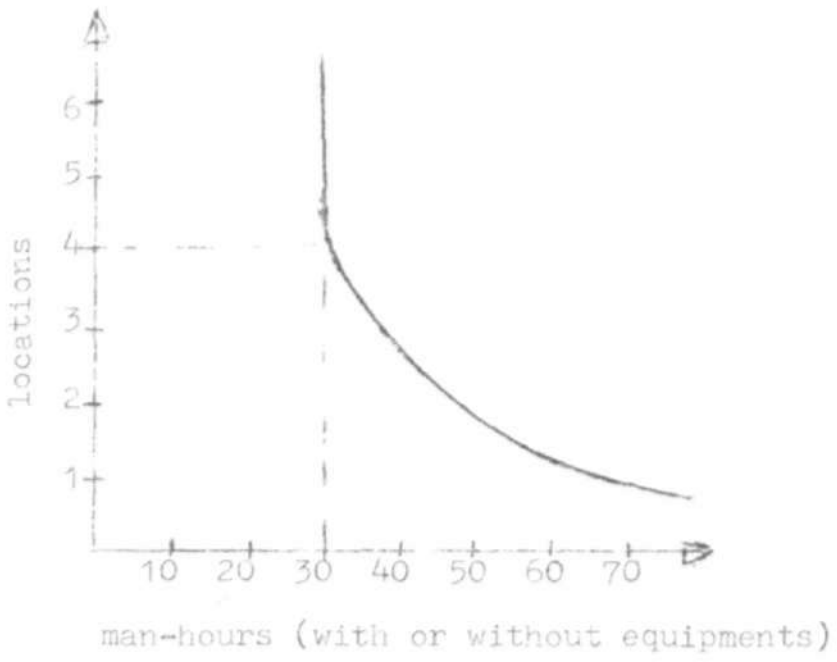


Fig. 4.3 - A plot of locations against man-hours employed.

This diagram shows that initially in location 1, 60 man-hours were expended to do a job and as other locations were advanced to this, quantity diminished for the same work task. At location 4 the optimum performance was reached and the same inputs were expended in higher locations.

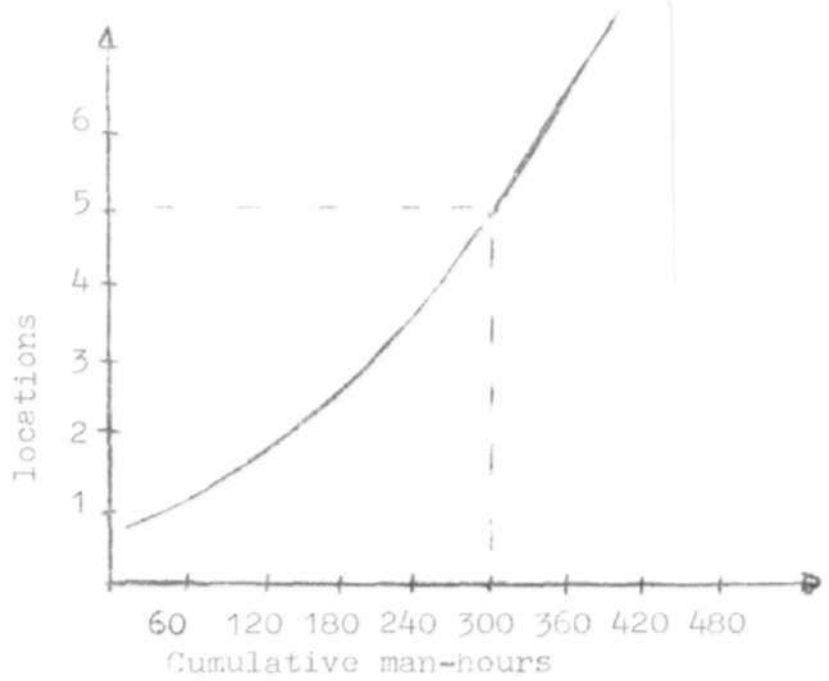


Fig 4.4 A plot of locations against cumulative man-hours.

Figure 4.4 shows that at location 1, 60 man-hours was expended and that at location 5, at optimum performance level was reached at a cumulative of 300 man-hours. Thus a constant rate of increase was maintained through the other higher locations. This is represented by the straight line portion of the graph.

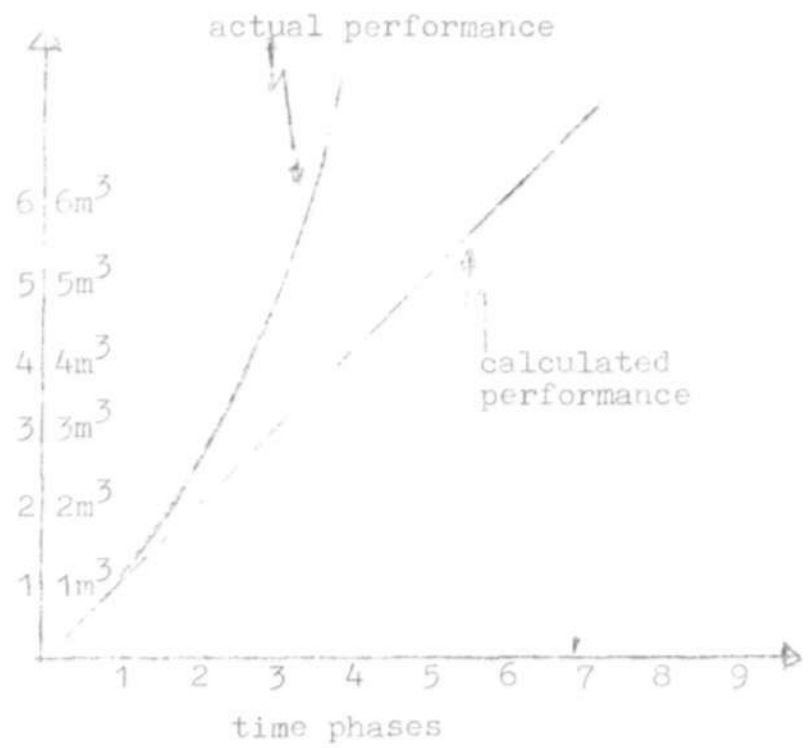


Fig. 4.5 - A plot of locations/volume of work against time phases.

This diagram shows a graph of actual and calculated performance at the difierent time phases.

With all the figures described the work squad functional manager will be able to make his own economic plan with an aim to maximize profit. This in itself will also enable researches.

4.2.3 Time phase: This term denotes time of operation of work task relative to other times in and out of operation. That is time in-phase in hours or days, or weeks etc. with respect to other times in or out of phase in hours, or days or weeks etc. respectively of work task.

The time phases in the examples 4.3.1 and 4.3.2 represent a day each.

4.2.4 Operation duration: This term refers to the time taken to complete a work task.

It is based on data obtained from productivity records and work study records. These data are then modified to suit the project plan based on the following factors:

(a) Overall project duration (anticipated or imagined)

(b) Possibility of task/capacity of work squad.

(c) Cost of task (operation)

(d) Materials required

(e) Equipment required

(f) Consideration of other tasks

(g) Contingencies (also flexibility allowance)

4.3 Application of model incorporating local constraints (Methodology)

Two examples will be showed, explaining the application of the matrix organization approach model to the planning of building works.

The construction of a housing estate and a high rise building will be used in this case.

For both buildings the construction of the frames will be considered first, after which the cladding, partitioning and finishing operations will be considered. External works will be considered last. The placement of time phases will follow this pattern.

Flexibility and contingency allowances will be very much incorporated, taking cognizance of the situation in Nigeria now.

The overall project duration can be drastically reduced depending on the following main factors:

(a) Type of Construction/Technology to be employed.

(b) Capability of work squads.

(c) Type of materials to be used.

(d) Cost of tasks (operations)

(e) Availability/cost of materials required.

(f) Availability/cost of equipments required.

4.3.1 Application of matrix organization approach model to the construction of a large number of housing units, say 100 units of 3 bedroom bungalows (10 units to be taken for convenience sake).

This is an example of a case of horizontal locations. Each housing unit is a location, thus there are 10 locations in the case of 10 units.

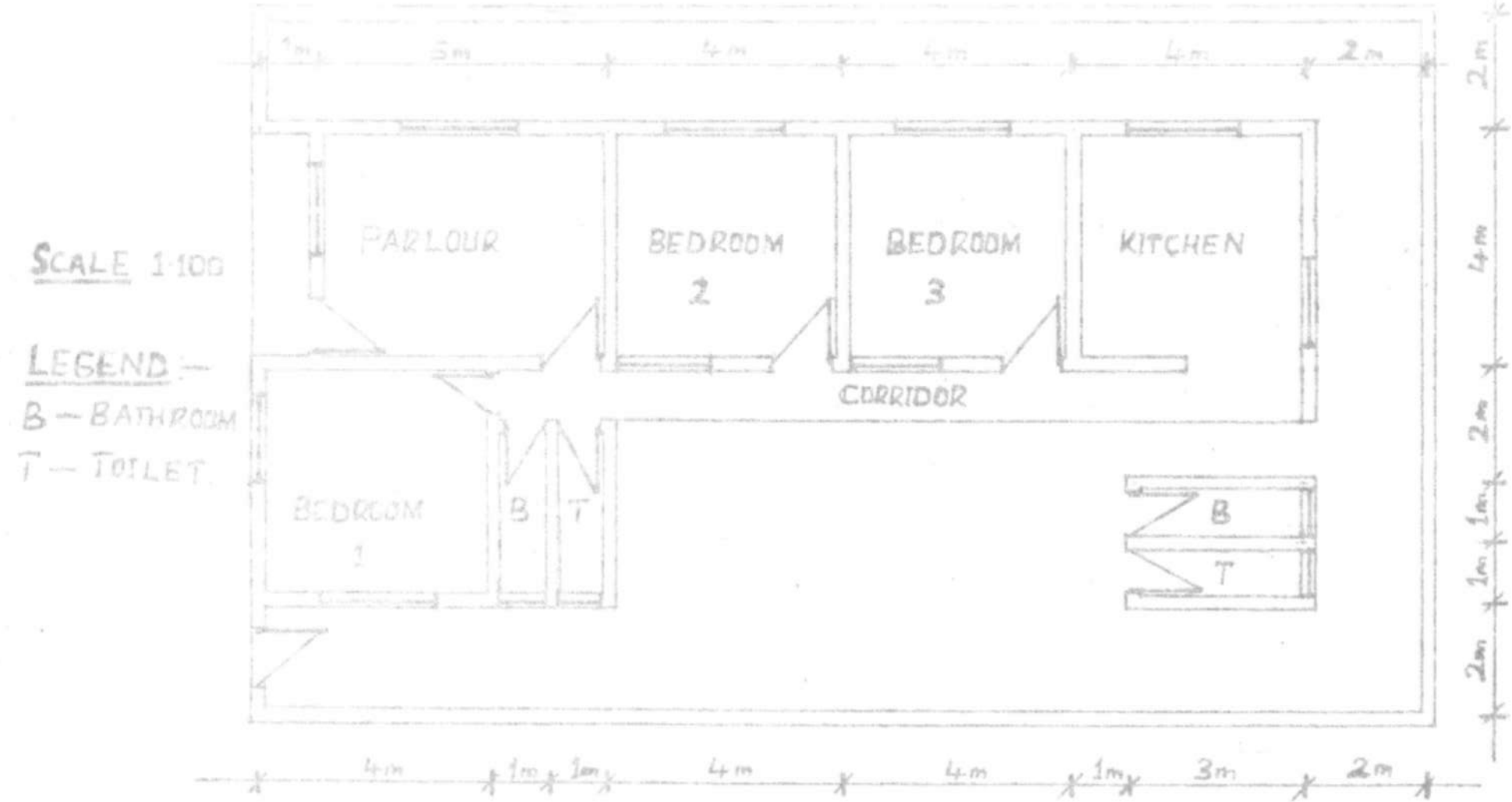


Fig. 4-6 — Plan of a three bedroom block unit of a housing estate.

	Task type	Specification	Work Squad	Equipment	Total Duration
1	Preliminaries	This involves the following: Selection of work squads. Provision of contract documents and drawings to work squad. Consultations with work squads. Agreements with clients. Agreements with work squads. Site mobilization. Raising of funds. Arrangements for the supply of materials with the consent of the respective work squads etc.	-		7 days
2	Setting-out	Setting out of a three bedroom bungalow and fence with an error of ± 001 mm	1	Theodolite Staff, Poles, Steel-tape.	$\frac{1 \times 10}{10}$

	Task Type	Specification	Work Squad	Equipment	Total Duration
3	Excavation	Excavation of fence and foundation trenches as in plan. Depth of trenches should be 90 cm minimum for foundation trenches and 70 cm for fench trenches.	2	- (manual operations)	1 x 10 / 10
4	Concreting	Provision of mass concrete for strip foundation and ground floor slab.	3	Agitator mixer	10 10
1		Provision of reinforced concrete for lintel and and ring beam.		suitable placement equipment.	10 30
		Provision of form work required.			30
5	Block work	All block work in house from foundation to ring beam level, and fencing of surrounding.	4	-	11 13 10 34

	Task type	Specification	Work Squad	Equipment	Total Duration
6	Laterite-filling and ramming	Filling of slab base with earth and back filling of building surroundings generally. Ramming of slab base to required strength. Rock laterite is to be used.	2	Ramming machine	11
7	Steel fixing.	Formation of reinforcement for lintels and ring beam.	5	steel-cutter. Iron-bender	10 10 — 20
8	Roofing	Construction of rafters and purlins and fixing of roof covering.	6	Crane probably	16
	Fixing of Doors and windows	Hanging of frames Fixing of doors with locks and windows	6	- -	10 11 — 21

	Task type	Specification	Work Squad	Equipment	Total Duration
9	Ceiling operations.	Frabication of ceiling frame and ceiling with asbestos ceiling sheet.	6		11 11 22
10	Electrical works and installations	All electrical works and installations as in electrical drawings and specifications.	7	Iron-bender Iron-cutter	16 16 32
11	Plumbing works and installations	All plumbing works and installation as specified in machanical drawings	8	cutting machine Iron-bender	16 16 32
12	Wall rendering and Floor finishing	All wall rendering with mortar and fixing of coping on on wall of fence All floor finishing with mortar	9 9	- -	16

	Task type	Specification	Work Squad	Equipment	Total Duration
14	Painting work.	3 coats of painting all over the house and fence.	10	-	13
15	Glazing work	Fixing of glasses to windows	11	glass-cutter	11
16	Cleaning of site	All cleaning work in and out, the house in rendiness for handing over	-	-	11

LOCATION 1 FRAME

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	- M.T.	-
2	Setting-out	1	1	1
3	Excavation (foundation)	1	2^a	2
4	Concreting (foundation)	1	3^a	3
5	Blockwork (up to d.p.c.)	2	4^a	4
6	Laterite filling, Back filling and Ramming	2	2^b	6
7	Concreting (Ground floor slab)	1	3^b	8
8	Blockwork (up to lintel level)	4	4^b	9
9	Steel fixing (lintels)	1	5^a	13
10	Concreting (lintels)	1	3^c	14
11	Blockwork (up to ring beam level)	1	4^c	15
12	Steel fixing (Ring beam)	1	5^b	16
13	Concreting (Ring beam)	1	3^d	17
14	Roofing (Rafter, Purlins and Covering)	7	6^a	18
15	Window and Door frames (fixing)	1	6^b	25
16	Ceiling frame	2	6^c	26
17	Electrical work	7	7^a	28*
18	Plumbing work	7	8^a	28*
19	Wall and floor rendering	7	9	35

* - Indicates two or more operations going on simultaneously in the same location, i.e. at the same time phase.

M.T. - Master Team (General Contractor and team).

LOCATION 1 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	42
21	Hanging of doors with locks and windows	2	6[e]	44
22	Painting work	4	10	46
23	Glazing	2	11	50
24	Electrical Installations	7	7[b]	52*
25	Plumbing Installations	7	8[b]	52*
26	Cleaning and handing over of site	2	MT	60
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	2
28	Concreting (fence foundation)	1	3[a]	3
29	Blockwork	2	4[a]	4
30	Rendering and fixing of copings	2	9	35
31	Painting	2	10	46

LOCATION 2

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	MT	-
2	Setting-out	1	1	2
3	Excavation (foundation)	1	2[a]	3
4	Concreting (foundation)	1	3[a]	4
5	Blockwork (up to d.p.c.)	2	4[a]	5
6	Laterite filling, Back filling and Ramming	2	2[b]	7
7	Concreting (Ground floor slab)	1	3[b]	9
8	Blockwork (up to lintel level)	4	4[b]	10
9	Steel fixing (lintels)	1	5[a]	14
10	Concreting (lintels)	1	3[c]	15
11	Blockwork (up to ring beam level)	1	4[c]	16
12	Steel fixing (Ring beam)	1	5[b]	17
13	Concreting (ring beam)	1	3[d]	18
14	Roofing (Rafter, Purlins and Covering)	7	6[a]	19
15	Window and Door frames (fixing)	1	6[b]	26
16	Ceiling frame	2	6[c]	27
17	Electrical work	7	7[a]	29*
18	Plumbing work	7	8[a]	29*
19	Wall and floor rendering	7	9	36

LOCATION 2 (Contd.)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	43
21	Hanging of doors with locks and windows	2	6[e]	45
22	Painting work	4	10	47
23	Glazing	2	11	51
24	Electrical Installations	7	7[b]	53*
25	Plumbing Installations	7	8[b]	53*
26	Cleaning and handing over of site	2	M.T.	61
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	3
28	Concreting (fence foundation)	1	3[a]	4
29	Blockwork	2	4[a]	5
30	Rendering and fixing of copings (fence)	2	9	36
31	Painting	2	10	47

LOCATION 3

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	M.T.	-
2	Setting-out	1	1	3
3	Excavation (foundation)	1	2[a]	4
4	Concreting (foundation)	1	3[a]	5
5	Blockwork (up to d.p.c.)	2	4[a]	6
6	Laterite filling, Black filling and Ramming	2	2[b]	8
7	Concreting (Ground floor slab)	1	3[b]	10
8	Blockwork (up to lintel level)	4	4[b]	11
9	Steel fixing (lintels)	1	5[a]	15
10	Concreting (lintels)	1	3[c]	16
11	Blockwork (up to ring beam level)	1	4[c]	17
12	Steel fixing (Ring beam)	1	5[b]	18
13	Concreting (Ring beam)	1	3[d]	19
14	Roofing (Rafter, Purlins and Covering)	7	6[a]	20
15	Window and Door frames (fixing)	1	6[b]	27
16	Ceiling frame	2	6[c]	28
17	Electrical work	7	7[a]	30*
18	Plumbing work	7	8[a]	30*
19	Wall and floor rendering	7	9	37

LOCATION 3 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	44
21	Hanging of doors with locks and windows	2	6[e]	46
22	Painting work	4	10	48
23	Glazing	2	11	52
24	Electrical Installations	7	7[b]	54*
25	Plumbing Installations	7	8[b]	54*
26	Cleaning and handing over of site	2	M.T.	62
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	4
28	Concreting (fence foundation)	1	3[a]	5
29	Blockwork	2	4[a]	6
30	Rendering and fixing of copings (fence)	2	9	37
31	Painting	2	10	48

LOCATION 4

(FRAME)

Serial Number	Time type	Duration	Work squad	Time phase
1	Preliminaries	7	M.T.	-
2	Setting-out	1	1	4
3	Excavation (foundation)	1	2^a	5
4	Concreting (foundation)	1	3^a	6
5	Blockwork (up to d.p.c.)	2	4^a	7
6	Laterite filling, Back filling and Ramming	2	2^b	9
7	Concreting (Ground floor slab)	1	3^b	11
8	Blockwork (up to lintel level)	4	4^b	12
9	Steel fixing (lintels)	1	5^a	16
10	Concreting (lintels)	1	3^c	17
11	Blockwork (up to ring beam level)	1	4^c	18
12	Steel fixing (Ring beam)	1	5^b	19
13	Concreting (Ring beam)	1	3^d	20
14	Roofing (Rafter, Purlins and Covering)	7	6^a	21
15	Window and Door frames (fixing)	1	6^b	28
16	Ceiling frame	2	6^c	29
17	Electrical work	7	7^a	31*
18	Plumbing work	7	8^a	31*
19	Wall and floor rendering	7	9	38

LOCATION 4 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbetos ceiling	2	6[d]	45
21	Hanging of doors with locks and windows	2	6[e]	47
22	Painting work	4	10	49
23	Glazing	2	11	53
24	Electrical Installations	7	7[b]	55*
25	Plumbing Installations	7	8[b]	55*
26	Cleaning and handing over of site	2	M.T.	63
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	5
28	Concreting (fence foundation)	1	3[a]	6
29	Blockwork	2	4[a]	7
30	Rendering and fixing of copings (fence)	2	9	38
31	Painting	2	10	49

LOCATION 5

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	N.T.	-
2	Setting-out	1	1	5
3	Excavation (foundation)	1	2^a	6
4	Concreting (foundation)	1	3^a	7
5	Blockwork (up to d.p.c.)	2	4^a	8
6	Laterite filling, Back filling and Ramming	2	2^b	10
7	Concreting (Ground floor slab)	1	3^b	12
8	Blockwork (up to lintel level)	4	4^b	13
9	Steel fixing (lintels)	1	5^a	17
10	Concreting (lintels)	1	3^c	18
11	Blockwork (up to ring beam level)	1	4^c	19
12	Steel fixing (Ring beam)	1	5^c	20
13	Concreting (Ring beam)	1	3^d	21
14	Roofing (Rafter, Purlins and Covering)	7	6^a	22
15	Window and Door frames (fixing)	1	6^b	29
16	Ceiling frame	2	6^c	30
17	Electrical work	7	7^a	32*
18	Plumbing work	7	8^a	32*
19	Wall and floor rendering	7	9	39

LOCATION 5 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	46
21	Hanging of doors with locks and windows	2	6[e]	48
22	Painting work	4	10	50
23	Glazing	2	11	54
24	Electrical Installations	7	7[b]	56*
25	Plumbing Installations	7	8[b]	56*
26	Cleaning and handing over of site	2	M.T.	64
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	6
28	Concreting (fence foundation)	1	3[a]	7
29	Blockwork	2	4[a]	8
30	Rendering and fixing of copings (fence)	2	9	39
31	Painting	2	10	50

LOCATION 6

(FRAME)

Serial Number	Task type	Duration	Work. squad	Time phase
1	Preliminaries	7	M.T.	-
2	Setting-out	1	1	6
3	Excavation (foundation)	1	2^a	7
4	Concreting (foundation)	1	3^a	8
5	Blockwork (up to d.p.c.)	2	4^a	9
6	Laterite filling, Back-filling and Ramming	2	2^b	11
7	Concreting (Ground floor slab)	1	3^b	13
8	Blockwork (up to lintel level)	4	4^b	14
9	Steel fixing (lintels)	1	5^a	18
10	Concreting (lintels)	1	3^c	19
11	Blockwork (up to ring beam level)	1	4^c	20
12	Steel fixing (Ring beam)	1	5^b	21
13	Concreting (Ring beam)	1	3^d	22
14	Roofing (Rafter, Purlins and Covering)	7	6^a	23
15	Window and Door frames (fixing)	1	6^b	30
16	Ceiling frame	2	6^c	31
17	Electrical work	7	7^a	33*
18	Plumbing work	7	8^a	33*
19	Wall and floor rendering	7	9	40

LOCATION 6 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad.	Time phase
20	Asbestos ceiling	2	6[d]	47
21	Hanging of doors with locks and windows	2	6[e]	49
22	Painting work	4	10	51
23	Glazing	2	11	55
24	Electrical Installations	7	7[b]	57*
25	Plumbing Installations	7	8[b]	57*
26	Cleaning and handing over of site	2	M.T	65
		(External	Works)	
27	Excavation (fence foundation)	1	2[a]	7
28	Concreting (fence foundation)	1	3[a]	8
29	Blockwork	2	4[a]	9
30	Rendering and fixing of copings (fence)	2	9	4[illegible]
31	Painting	2	10	51

LOCATION 7

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	M.T.	-
2	Setting-out	1	1	7
3	Excavation (foundation)	1	2[a]	8
4	Concreting (foundation)	1	3[a]	9
5	Blockwork (up to d.p.c.)	2	4[a]	10
6	Laterite filling, Back filling and Ramming	2	2[b]	12
7	Concreting (Ground floor slab)	1	3[b]	14
8	Blockwork (up to lintel level)	4	4[b]	15
9	Steel fixing (lintels)	1	5[a]	19
10	Concreting (lintels)	1	3[c]	20
11	Blockwork (up to ring beam level)	1	4[c]	21
12	Steel fixing (Ring beam)	1	5[b]	22
13	Concreting (Ring beam)	1	3[d]	23
14	Roofing (Rafter, Purlins and Covering)	7		24
15	Window and Door frames (fixing)	1	6[b]	31
16	Ceiling frame	2	6[c]	32
17	Electrical work	7	7[a]	34*
18	Plumbing work	7	8[a]	34*
19	Wall and floor rendering	7	9	41

LOCATION 7 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	48
21	Hanging of doors with locks and windows	2	6[e]	50
22	Painting work	4	10	52
23	Glazing	2	11	56
24	Electrical Installations	7	7[b]	58*
25	Plumbing Installations	7	8[b]	58*
26	Cleaning and handing over of site	2	M.T	66
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	8
28	Concreting (fence foundation)	1	3[a]	9
29	Blockwork	2	4[a]	10
30	Rendering and fixing of copings (fence)	2	9	41
31	Painting	2	10	52

LOCATION 8

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	M.T.	-
2	Setting-out	1	1	8
3	Excavation (foundation)	1	2^a	9
44	Concreting (foundation)	1	3^a	10
55	Blockwork (up to d.p.c.)	2	4^a	11
66	Laterite filling, Back filling and Ramming	2	2^b	13
77	Concreting (Ground floor slab)	1	3^b	15
8	Blockwork (up to lintel level)	4	4^b	16
9	Steel fixing (lintels)	1	5^a	20
10	Concreting (lintels)	1	3^c	21
11	Blockwork (up to ring beam level)	1	4^c	22
12	Steel fixing (Ring beam)	1	5^b	23
13	Concreting (Ring beam)	1	3^d	24
14	Roofing (Rafter, Purlins and Covering)	7	6^a	25
15	Window and Door frames (fixing)	1	6^b	32
16	Ceiling frame	2	6^c	33
17	Electrical work	7	7^a	35*
18	Plumbing work	7	8^a	35*
19	Wall and floor rendering	7	9	42

LOCATION 8 (Contd.)

Serial Number	Task type	Duration (FRAME)	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	49
21	Hanging of doors with locks and windows	2	6[e]	51
22	Painting work	4	10	51
23	Glazing	2	11	57
24	Electrical Installations	7	7[b]	59*
25	Plumbing Installations	7	8[b]	59*
26	Cleaning and handing over of site	2	M.T	67
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	9
28	Concreting (fence foundation)	1	3[a]	10
29	Blockwork	2	4[a]	11
30	Rendering and fixing of copings (fence)	2	9	42
31	Painting	2	10	53

LOCATION 9

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	M.T.	-
2	Setting-out	1	1	9
3	Excavation (foundation)	1	2^a	10
4	Concreting (foundation)	1	3^a	11
5	Blockwork (up to d.p.c.)	2	4^a	12
6	Laterite filling, Back filling and Ramming	2	2^b	14
7	Concreting (Ground floor slab)	1	3^b	16
8	Blockwork (up to lintel level)	4	4^b	17
9	Steel fixing (lintels)	1	5^a	21
10	Concreting (lintels)	1	3^c	22
11	Blockwork (up to ring beam level)	1	4^c	23
12	Steel fixing (Ring beam)	1	5^b	24
13	Concreting (Ring beam)	1	3^d	25
14	Roofing (Rafter, Purlins and Covering)	7	6^a	26
15	Window and Door frames (fixing)	1	6^b	33
16	Ceiling frame	2	6^c	34
17	Electrical work	7	7^a	36*
18	Plumbing work	7	8^a	36*
19	Wall and floor rendering	7	9	43

LOCATION 9 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	50
21	Hanging of doors with locks and windows	2	6[e]	52
22	Painting work	4	10	54
23	Glazing	2	11	58
24	Electrical Installations	7	7[b]	60*
25	Plumbing Installations	7	8[b]	60*
26	Cleaning and handing over of site	2	M.T.	68
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	10
28	Concreting (fence foundation)	1	3[a]	11
29	Blockwork	2	4[a]	12
30	Rendering and fixing of copings (fence)	2	9	43
31	Painting	2	10	54

LOCATION 10

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	M.T.	-
2	Setting-out	1	1	10
3	Excavation (foundation)	1	2[a]	11
4	Concreting (foundation)	1	3[a]	12
5	Blockwork (up to d.p.c.)	2	4[a]	13
6	Laterite filling, Back filling and Ramming	2	2[b]	15
7	Concreting (Ground floor slab)	1	3[b]	17
8	Blockwork (up to lintel level)	4	4[b]	18
9	Steel fixing (lintels)	1	5[a]	22
10	Concreting (lintels)	1	3[c]	23
11	Blockwork (up to ring beam level)	1	4[c]	24
12	Steel fixing (Ring beam)	1	5[b]	25
13	Concreting (Ring beam)	1	3[d]	26
14	Roofing (Rafter, Purlins and Covering)	7	6[a]	27
15	Window and Door frames (fixing)	1	6[b]	34
16	Ceiling frame	2	6[c]	35
17	Electrical work	7	7[a]	37*
18	Plumbing work	7	8[a]	37*
19	Wall and floor rendering	7	9	44

LOCATION 10 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
20	Asbestos ceiling	2	6[d]	51
21	Hanging of doors with locks and windows	2	6[e]	53
22	Painting	4	10	55
23	Glazing	2	11	59
24	Electrical Installations	7	7[b]	61*
25	Plumbing Installations	7	8[b]	61*
26	Cleaning and handing over of site	2	M.T.	
		(External Works)		
27	Excavation (fence foundation)	1	2[a]	11
28	Concreting (fence foundation)	1	3[a]	12
29	Blockwork	2	4[a]	15
30	Rendering and fixing of copings (fence)	2	9	44
31	Painting	2	10	55

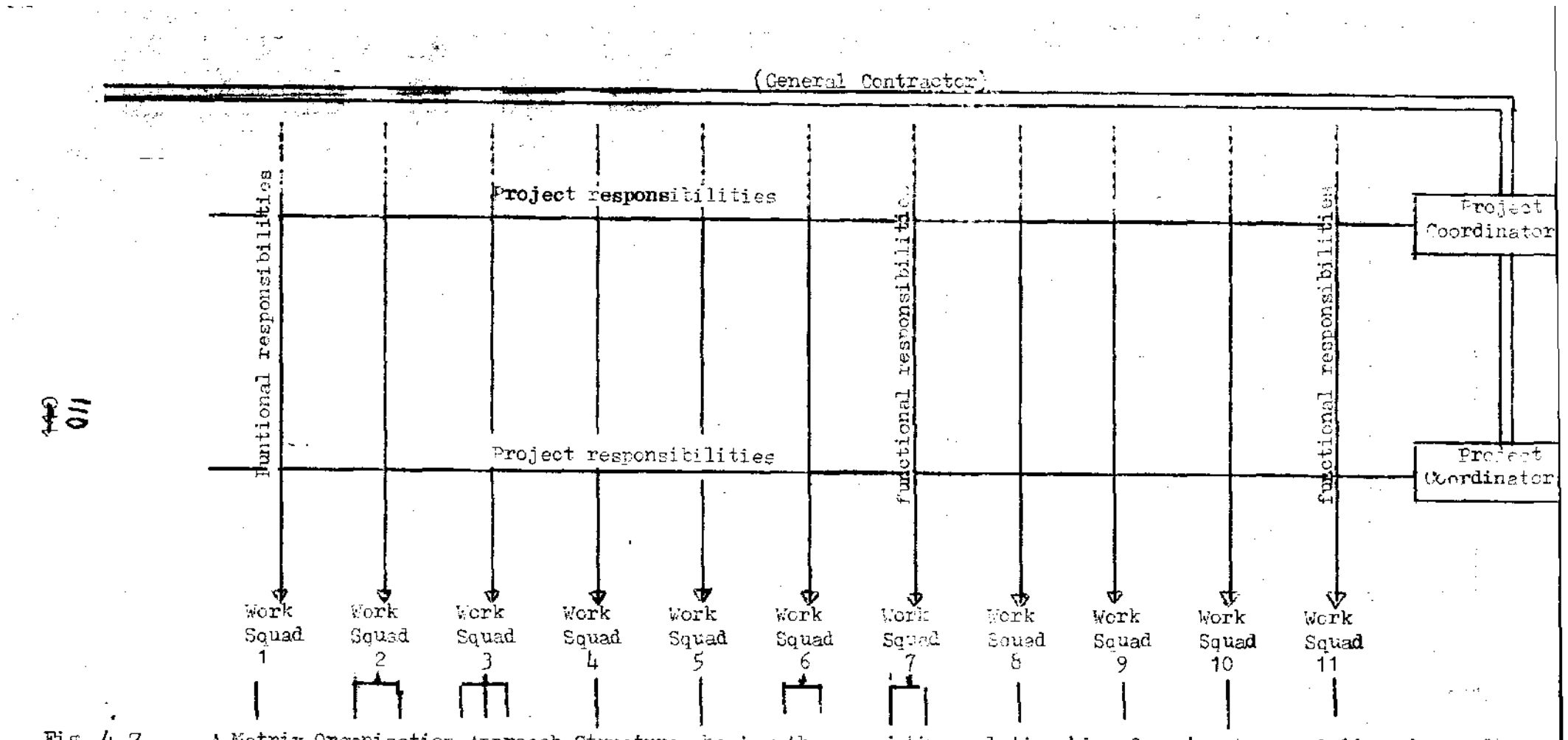


Fig. 4.7 A Matrix Organization Approach Structure showing the supporting relationship of master team and 11 work squads.

The master team is made up of the general contractor and his project coordinators.

Work squads:

1 - Setting out	4 - Block work	7 - Electrical operations	10 - Painting work
2 - Excavation & filling	5 - Steel fixing work	8 - Plumbing operations	11 - Glazing work
3 - Concreting works	6 - Capentry & Jointry	9 - Wall & floor finishing	12 - ——

Matrix Organization Approach network (model) showing the sequence and Inter-relationship between the various operations and their work squads in different locations. Each box represents a work package.



(Fig. 4.8)

LEGEND: → Arrow denotes continuation and ending of task by work squad.

□ Box denotes work package, which expresses task type, work squad, location and time phase e.g. $2^{b}1$ { work squad 2, task type 2, location 1, time phase 6

Figure 4.6 is a matrix organization approach model showing the sequence and inter-relationship of work tasks (operations) and their respective work squads in the different horizontal locations and with respect to their time phases.

Every matrix box is a work package describing

(a) Task type

(b) Corresponding work squad

(c) Location

(d) Time phase.

In this figure, starting from location 1 there is the setting-out work squad (work squad 1) in operation, in time phase 1. This is followed by work squad 2^a which is in charge of excavation; work squad 3^a which is in charge of concreting; work squad 4^a which is in charge of blockworks, and so on up to work squad 7^a and 8^a which are in charge of electrical and plumbing operations respectively. All these work tasks and their corresponding work squad exist in different time phases. This sequence is repeated in other locations ranging from 2 to 10.

Work squad 7^a and 8^a are operating simultaneously with the same time phases and this repeats itself in the different locations.

The arrows in the figure denotes continuation and ending of tasks by work squads.

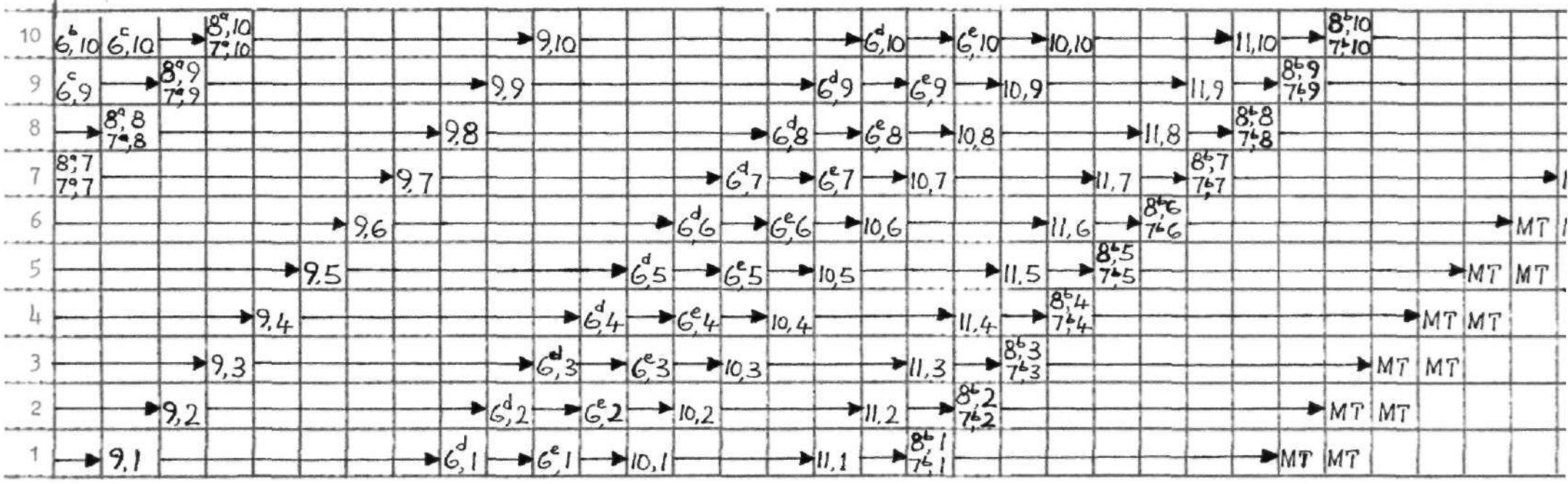
The blank spaces denotes that there are no operations and of course no work squads.

See 4.2.2 on page 76 for a detailed explanation of the lettering used here.

Work squads:

1 - Setting out	4 - Block work	7 - Electrical operations	10 - Painting work
2 - Excavation & filling	5 - Steel fixing work	8 - Plumbing operations	11 - Glazing work
3 - Concreting works	6 - Capentry & Jointry	9 - Wall & floor finishing	12 - ——

Matrix Organization Approach network (model) showing the sequence and Inter-relationship between the various operations and their work squads in different locations. Each box represents a work package.



(Fig. 4.9)

LEGEND: ⟶ Arrow denotes continuation and ending of task by work squad.

□ Box denotes work package, which expresses task type, work squad, location and time phase e.g. $2^{b}1$ — work squad 2, task type 2, location 1, time phase 6

MT — Master Team

Figures 4.9 and 4.10 are continuations of figure 4.8 and simply show the continuation from figure 4.8 of the sequence and inter-relationship of work tasks and their corresponding work squads in different horizontal locations with respect to their time phases. This follows from work squad 9 to 6^d, 6^e, 10, 11, 7^b and 8^b, to Master team (MT) which is the final operation on this location and concerns the cleaning and handing over of site. These operations are repeated in other locations up to location 10 which is the last location.

As shown in figure 4.10, the handing over of the tenth housing unit will be done on the 70th day from the start of operations.

The different work squads can also do their own planning within the limits of figures 4.8 to 4.10.

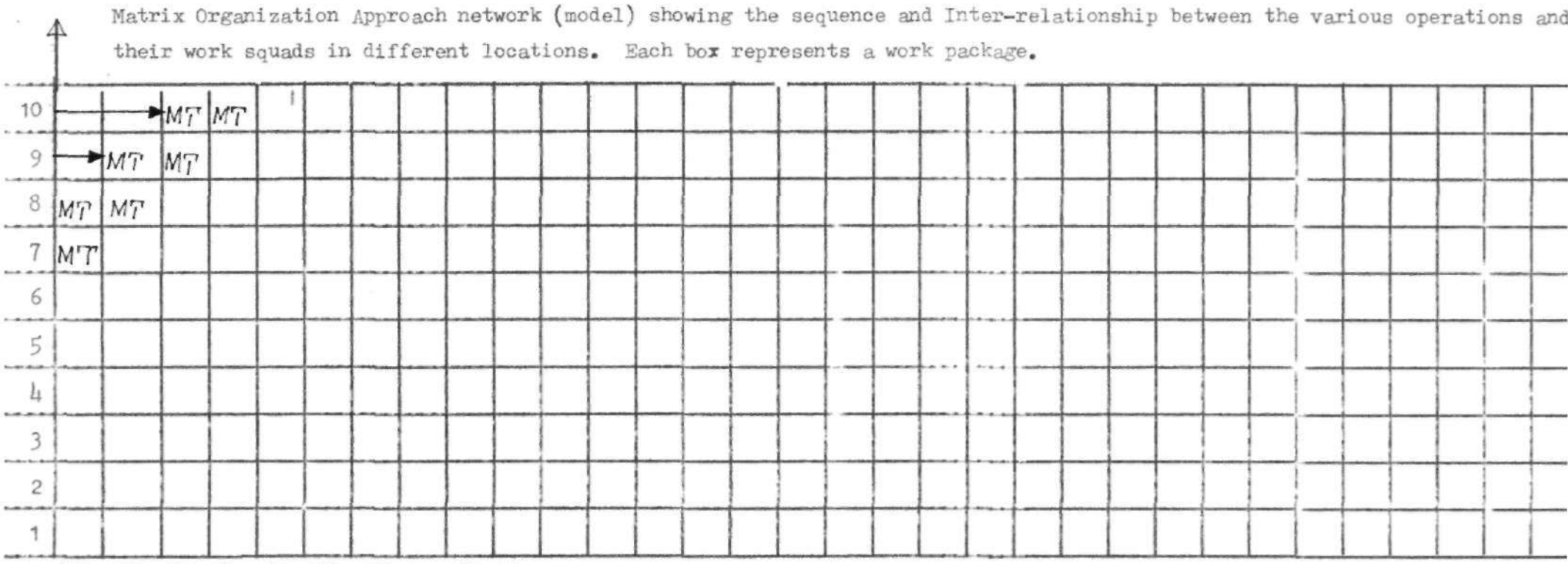
I advise the use of more simplistic and motion oriented models like a combination of bar chart and cyclic operation networks (cyclones).

See appendix C for other existing construction planning models.

Work squads:

1 - Setting out	4 - Block work	7 - Electrical operations	10 - Painting work
2 - Excavation & filling	5 - Steel fixing work	8 - Plumbing operations	11 - Glazing work
3 - Concreting works	6 - Capentry & Jointry	9 - Wall & floor finishing	12 - ——

Matrix Organization Approach network (model) showing the sequence and Inter-relationship between the various operations and their work squads in different locations. Each box represents a work package.



(Fig.4.10)

LEGEND: → Arrow denotes continuation and ending of task by work squad.

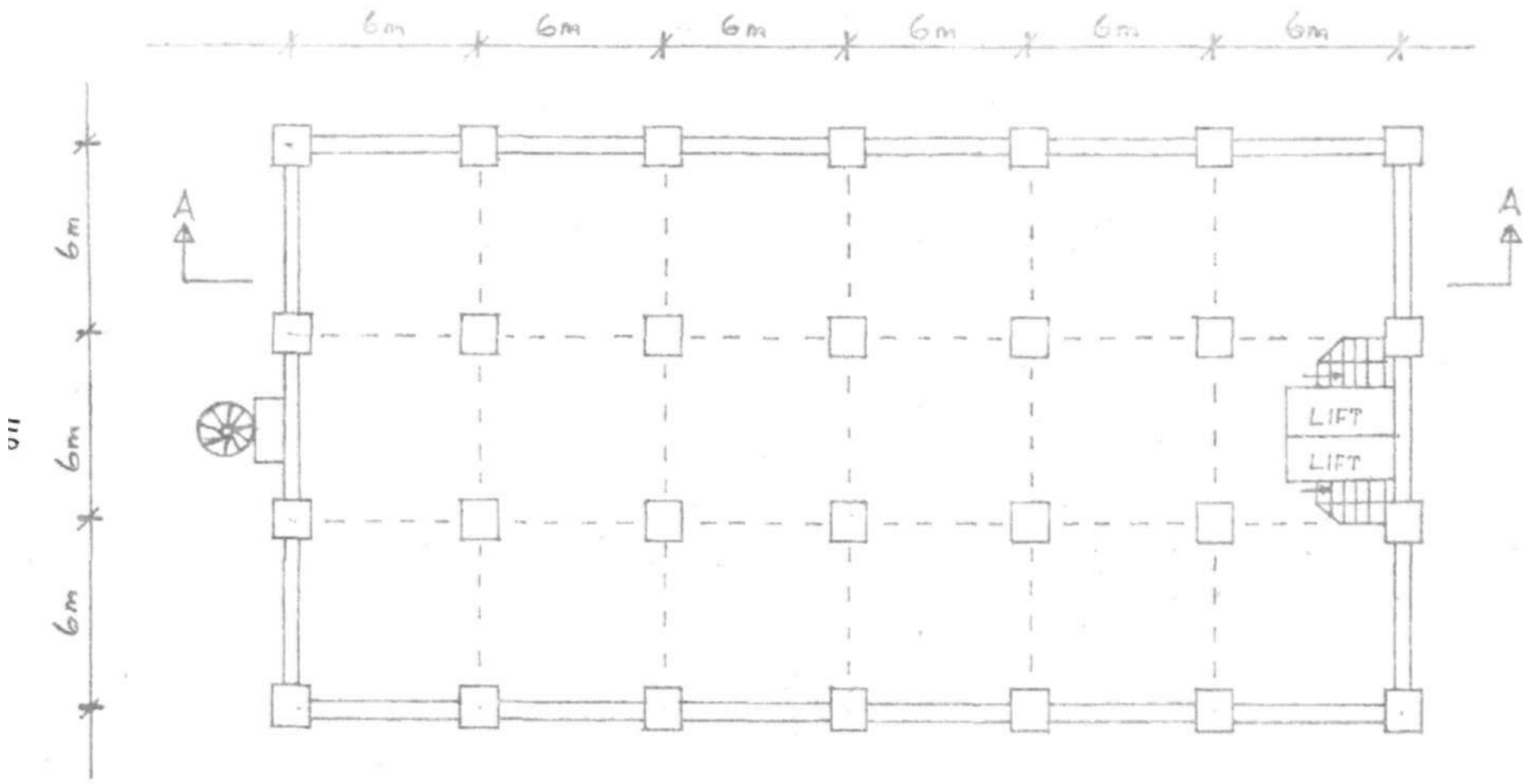
□ Box denotes work package, which expresses task type, work squad, location and time phase e.g. $2^{b}1$ { work squad 2, task type 2, location 1, time phase 6

MT

4.3.2. Application of matrix organization approach model to the construction of a 9-storey office building with a basement beneath.

This is an example of a case of vertical locations. Each floor is a location, thus, there are 11 locations. The surrounding ground as well as the basement will be taken as location 1.

The frame of this building will be done in cast insitu concrete.



g. 4-11 — Ground floor plan of a 9-storey office building with a basement underneath. This building is to be built with concrete columns, beams, and slabs, cast insitu. It will also be centrally airconditioned.

There will also be a blockwork fence surrounding the building. It will be 20 m from the building right round.

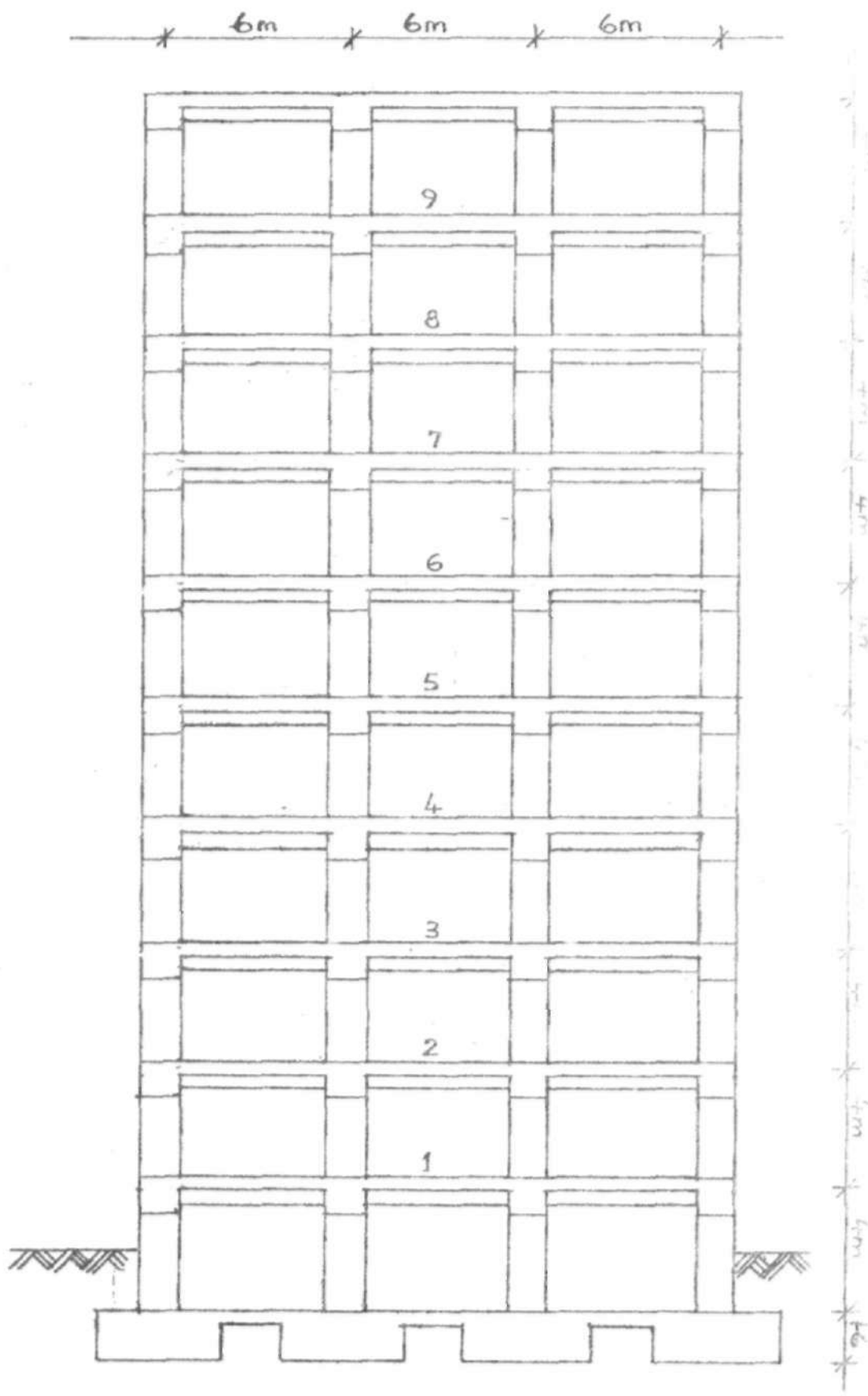


Fig. 4.12 — Cross sectional elevation of the 9-storey building.

	Task type	Specification	Work squad	Equipment	Total Duration
3	Excavation	This includes the excavation of the basement as in foundation plan and excavation of trenches for foundation of fence. Also included is the back-filling to the sides of the basement.	2	Earth-moving machines	10 1 5 15
4	Steel fixing	All steel works concerning basement, basement walls, columns, beams, slabs, and staircases up to the eleventh location (tenth floor).	3	Steel cutter. Steel bender	7 6 7 20 + 9 x 9 101
5	Concreting	Provision of reinforced concrete required for all the concreting works up to the tenth floor and also for the foundation of fence.	4	Agitator mixer. Crane or Concrete pumb.	13 + 5 x 9 58

	Task type	Specification	Work squad	Equipment	Total Duration
11	Wall and floor rendering and tiling operations	All wall and floor renderings with mortar up to the eleventh floor and tiling operations as specified in drawings. Rendering of fence is also included.	10	Crane mixer	8 + 7 x 9 71
12	Ceiling operations	Fabrication of suspended ceiling frame and ceiling with ceiling tiles as specified in building drawings and specifications.			7 x 9 63
13	Painting works	All painting works of building and fence as specified in painting schedule. 3 coats of texcote paint will be applied.	12	Form work	6 + 7 x 9 69

	Task type	Specification	Work squad	Equipment	Total Duration
13	Glazing works	The provision/ fixing of glasses to openings as in drawings. This work squad will work hand-in-hand with work squad 9. Since casement type of windows will be used and of aluminium products.	13	Crane perhaps	7 x 9 63
15	Fixing of curtain holders and fixing of rails for the stair-cases.	This involves fixing of curtain holders and rails to the staircases in the various floors of the building.	14	-	1 + 7 x 9 64
16	Road and Car park construction	This involves levelling, soil compaction, coal tarring and laying of asphalt.	15	Grader, Roller Truck Laying machine Coaltar tanker.	7

	Task type	Specification	Work squad	Equipment	Total Duratio
17	Laying of Bitumenous felt.	This entails laying of bitumenous felt on surface of last floor. This will be done in three layers.	16	-	2
18	Cleaning works	This entails general cleaning of all the floors and surroundings in readiness for handing over.	- Master team.	-	10

LOCATION 1

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Preliminaries	7	MT	
2	Setting-out (periphery of building and fence	1	1^a	1
3	Excavation (basement)	10	2^a	2
4	Setting-out (foundation of columns)	1	1^b	12
5	Excavation (foundation of columns)	1	2^b	13
6	Steel-fixing (foundations, walls, columns, beams and slab)	7	3^a	14
7	Concreting (foundations and basement)	3	4^a	21
8	Steel fixing (walls and columns)	6	3^b	24*
9	Form work (walls and columns)	7	5^a	24*
10	Concreting (walls and columns)	3	4^b	31
11	Form work (Beams and slabs)	3	5^b	34
12	Steel fixing (beams and slabs[1])	7	3^c	37
13	Electrical work	3	6^a	44*
14	Mechanical work	3	7^a	44*
15	Concreting (beams and slabs)	3	4^c	47

[1]slabs here mean Decking, Ramp and staircase.

M.T. - Master team.

* - Indicates two or more operations going on simultaneously in the same location, i.e. at the same time phase.

LOCATION 1 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
		(Finishing)		
16	Wall and floor rendering	4	10[a]	218
17	Painting works	3	12[a]	233
18	Electrical Installations	3	6[b]	240*
19	Mechanical Installations	3	7[b]	240*
20	Fixing of rails (for staircase)	1	14	249
		(External works)		
1	Excavation (fence)	4	2[c]	260
2	Concreting (fence)	4	4[d]	264
3	Blockwork (fence)	4	8	268
4	Rendering & fixing of copings	4	10[b]	272
5	Fixation of flood lights	2	6[c]	276
6	Levelling and soil compaction (Roads and Car park)			
7	Coal tarring (roads & car park)	7	15	278
8	Laying of asphalt (roads and car park)			
9	Painting (fence)	3	12[b]	285

LOCATION 2

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	50*
2	Form work (columns)	3	5[a]	50*
3	Concreting (columns)	2	4[a]	53
4	Form work (slab, staircase and beams)	4	5[b]	55
5	Steel fixing (slabs[2] and beams)	7	3[b]	59
6	Electrical work	3	6[a]	66*
7	Mechanical work	3	7[a]	66*
8	Concreting (slabs[2] & beams	3	4[b]	69
	(Cladding, Partitioning & Others)			
9	Block work	7	8	201
10	Electrical work	7	6[b]	208*
11	Mechanical work	7	7[b]	208*
12	Fixing of door & window frames	7	9[a]	215
13	Wall and floor rendering and tiling	7	10	222
14	Ceiling operations	7	11	229*
15	Hanging of doors with locks and windows	7	9[b]	229*

MT - Master team

* - Indicates two or more operations going on simultaneously in the same location, i.e. at the same time phase.

[2]Slabs here mean decking and stairoases.

LOCATION 2 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	236
17	Electrical Installations	7	6[c]	243*
18	Mechanical Installations	7	7[c]	243*
19	Glazing works	7	13	250*
20	Fixing of curtain holders and fixing of rails	7	14	250*
21	General cleaning	1	NT	305

LOCATION 3

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	72*
2	Form work (columns)	3	5[a]	72*
3	Concreting (columns)	2	4[a]	75
4	Form work (slab, staircase and beams)	4	5[b]	77
5	Steel fixing (slabs[2] & beams)	7	3[b]	81
6	Electrical work	3	6[a]	88*
7	Mechanical work	3	7[a]	88*
8	Concreting (slabs[2] & beams)	3	4[b]	91
	(Cladding, Partitioning & Others			
9	Block work	7	8	208
10	Electrical work	7	6[b]	215*
11	Mechanical work	7	7[b]	215*
12	Fixing of door & window frames	7	9[a]	222
13	Wall and floor rendering and tiling	7	10	229
14	Ceiling operations	7	11	236*
15	Hanging of doors with locks and windows	7	9[b]	236*

LOCATION 3 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	243
17	Electrical Installations	7	6[c]	250*
18	Mechanical Installations	7	7[c]	250*
19	Glazing works	7	13	257*
20	Fixing of curtain holders and fixing of rails	7	14	257*
21	General cleaning	1	MT	306

LOCATION 4

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	94*
2	Form work (columns)	3	5[a]	94*
3	Concreting (columns)	2	4[a]	97
4	Steel fixing (slab, staircase and beams)	4	5[b]	99
5	Steel fixing (slabs[2] & beams)	7	3[b]	103
6	Electrical work	3	6[a]	110*
7	Mechanical work	3	7[a]	110*
8	Concreting (slabs[2] & beams)	3	4[b]	113
	(Cladding, Partitioning & Others)			
9	Block work	7	8	215
10	Electrical work	7	6[b]	222*
11	Mechanical work	7	7[b]	222*
12	Fixing of door & window frames	7	9[a]	229
13	Wall and floor rendering and tiling	7	10	236
14	Ceiling operations	7	11	243*
15	Hanging of doors with locks and windows	7	9[b]	243*

LOCATION 4 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	250
17	Electrical Installations	7	6[c]	257*
18	Mechanical Installations	7	7[c]	257*
19	Glazing works	7	13	264*
20	Fixing of curtain holders and fixing of rails	7	14	264*
21	General cleaning	1	MT	307

LOCATION 5

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	116*
2	Form work (columns)	3	5[a]	116*
3	Concreting (columns)	2	4[a]	119
4	Form work (slab, staircase and beams)	4	5[b]	121
5	Steel fixing (slabs[2] & beams)	7	3[b]	125
6	Electrical work	3	6[a]	132*
7	Mechanical work	3	7[a]	132*
8	Concreting (slabs[2] & beams)	3	4[b]	135
	(Cladding, Partitioning & Others)			
9	Block work	7	8	222
10	Electrical work	7	6[b]	229*
11	Mechanical work	7	7[b]	229*
12	Fixing of door & window frames	7	9[a]	236
13	Wall and floor rendering and tiling	7	10	243
14	Ceiling operations	7	11	250*
15	Hanging of doors with locks and windows	7	9[b]	250*

LOCATION 5 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	257
17	Electrical Installations	7	6[c]	264*
18	Mechanical Installations	7	7[c]	264*
19	Glazing works	7	13	271*
20	Fixing of curtain holders and fixing of rails	7	14	271*
21	General cleaning	1	MT	308

LOCATION 6

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	138*
2	Form work (columns)	3	5[a]	138*
3	Concreting (columns)	2	4[a]	141
4	Formwork (slab, staircase and beams)	4	5[b]	143
5	Steel fixing (slabs[2] & beams)	7	3[b]	147
6	Electrical work	3	6[a]	154*
7	Mechanical work	3	7[a]	154*
8	Concreting (slabs[2] & beams)	3	4[b]	157
	(Cladding, Partitioning & Others)			
9	Block work	7	8	229
10	Electrical work	7	6[b]	236*
11	Mechanical work	7	7[b]	236*
12	Fixing of door & window frames	7	9[a]	243
13	Wall and floor rendering and tiling	7	10	250
14	Ceiling operations	7	11	257*
15	Hanging of doors with lc and windows	7	9[b]	257*

LOCATION 6 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	264
17	Electrical Installations	7	6[C]	271*
18	Mechanical Installations	7	7[C]	271*
19	Glazing works	7	13	278*
20	Fixing of curtain holders and fixing of rails	7	14	278*
21	General cleaning	1	MT	309

LOCATION 7

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	160*
2	Form work (columns)	3	5[a]	160*
3	Concreting (columns)	2	4[a]	163
4	Formwork (slab, staircase and beams)	4	5[b]	165
5	Steel fixing (slabs^2 & beams)	7	3[b]	169
6	Electrical work	3	6[a]	176*
7	Mechanical work	3	7[a]	176*
8	Concreting (slabs^2 & beams)	3	4[b]	179
	(Cladding, Partitioning & Others)			
9	Block work	7	8	236
10	Electrical work	7	6[b]	243*
11	Mechanical work	7	7[b]	243*
12	Fixing of door & window frames	7	9[a]	250
13	Wall and floor rendering and tiling	7	10	257
14	Ceiling operations	7	11	264*
15	Hanging of doors with locks and windows	7	9[b]	264*

LOCATION 7 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	271
17	Electrical Installations	7	6[c]	278*
18	Mechanical Installations	7	7[c]	278*
19	Glazing works	7	13	285*
20	Fixing of curtain holders and fixing of rails	7	14	285*
21	General cleaning	1	MT	310

LOCATION 8

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	182*
2	Form work (columns)	3	5[a]	182*
3	Concreting (columns)	2	4[a]	185
4	Formwork (slab, staircase and beams)	4	5[b]	187
5	Steel fixing (slabs[2] & beams)	7	3[b]	191
6	Electrical work	3	6[a]	198*
7	Mechanical work	3	7[a]	198*
8	Concreting (slabs[2] & beams)	3	4[b]	201
	(Cladding, Partitioning & Others)			
9	Block work	7	8	243
10	Electrical work	7	6[b]	250*
11	Mechanical work	7	7[b]	250*
12	Fixing of door & window frames	7	9[a]	257
13	Wall and floor rendering and tiling	7	10	264
14	Ceiling operations	7	11	271*
15	Hanging of doors with locks and windows	7	9[b]	271*

LOCATION 8 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	278
17	Electrical Installations	7	6[c]	285*
18	Mechanical Installations	7	7[c]	285*
19	Glazing works	7	13	292*
20	Fixing of curtain holders and fixing of rails	7	14	292*
21	General cleaning	1	MT	311

LOCATION 9

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3^a	204*
2	Form work (columns)	3	5^a	204*
3	Concreting (columns)	2	4^a	207
4	Form work (slab, staircase and beams)	4	5^b	209
5	Steel fixing (slabs^2 & beams)	7	3^b	213
6	Electrical work	3	6^a	220*
7	Mechanical work	3	7^a	220*
8	Concreting (slabs^2 & beams)	3	4^b	223
	(Cladding, Partitioning & Others)			
9	Block work	7	8	250
10	Electrical work	7	6^b	257*
11	Mechanical work	7	7^b	257*
12	Fixing of door & window frames	7	9^a	264
13	Wall and floor rendering and tiling	7	10	271
14	Ceiling operations	7	11	278*
15	Hanging of doors with locks and windows	7	9^b	278*

LOCATION 9 (Contd.)

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	285
17	Electrical Installations	7	6[C]	292*
18	Mechanical Installations	7	7[C]	292*
19	Glazing works	7	13	299*
20	Fixing of curtain holders and fixing of rails	7	14	299*
21	General cleaning	1	MT	312

at

LOCATION 10

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Steel fixing (columns)	2	3[a]	226*
2	Form work (columns)	3	5[a]	226*
3	Concreting (columns)	2	4[a]	229
4	Form work (slab, staircase and beams)	4	5[b]	231
5	Steel fixing (slabs[2] & beams)	7	3[b]	235
6	Electrical work	3	6[a]	242*
7	Mechanical work	3	7[a]	242*
8	Concreting (slabs[2] & beams)	3	4[b]	245
	(Cladding, Partitioning & Others)			
9	Block work	7	8	257
10	Electrical work	7	6[b]	264*
11	Mechanical work	7	7[b]	264*
12	Fixing of door & window frames	7	9[a]	271
13	Wall and floor rendering and tiling	7	10	278
14	Ceiling operations	7	11	285*
15	Hanging of doors with locks and windows	7	9	285*

LOCATION 10 (Contd.)

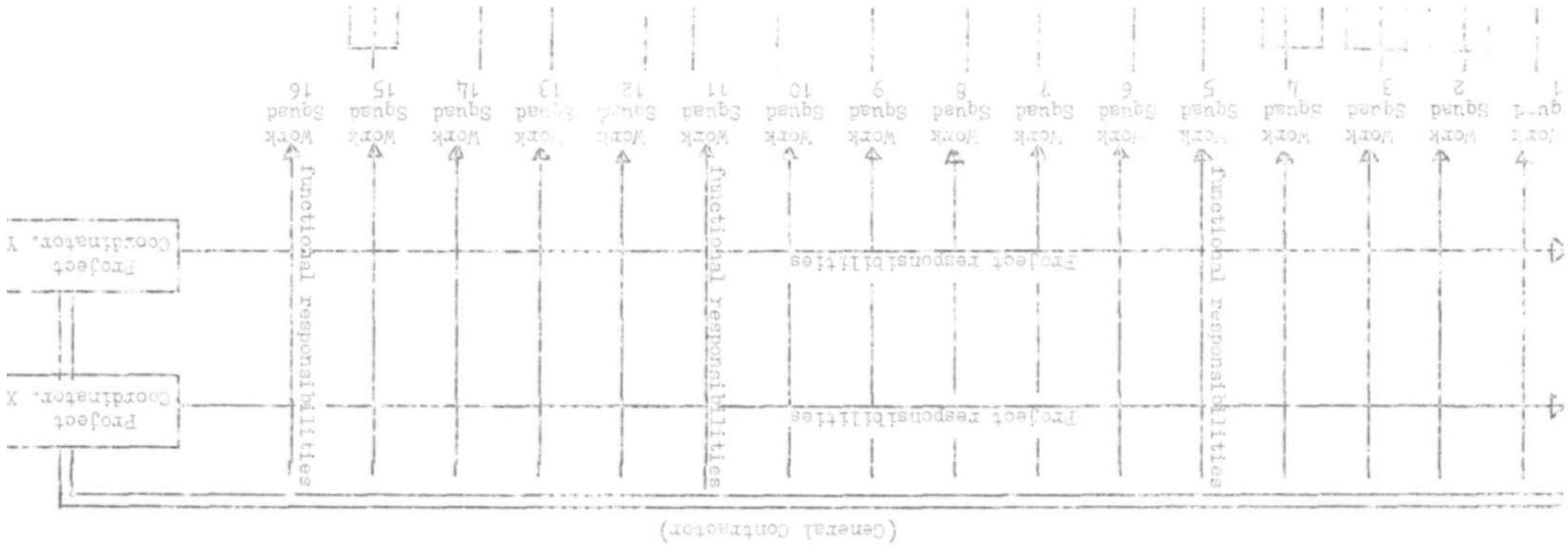
(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
16	Painting works	7	12	292
17	Electrical Installations	7	6[c]	299*
18	Mechanical Installations	7	7[c]	299*
19	Glazing works	7	13	306*
20	Fixing of curtain holders and fixing of rails	7	14	306*
21	General cleaning	1	MT	313

LOCATION 11

(FRAME)

Serial Number	Task type	Duration	Work squad	Time phase
1	Curing	7	-	248
2	Laying of bitumenous felt	2	16	255
3	Electrical work and Installations	3	6	257*
4	Mechanical work and Installations	3	7	257*

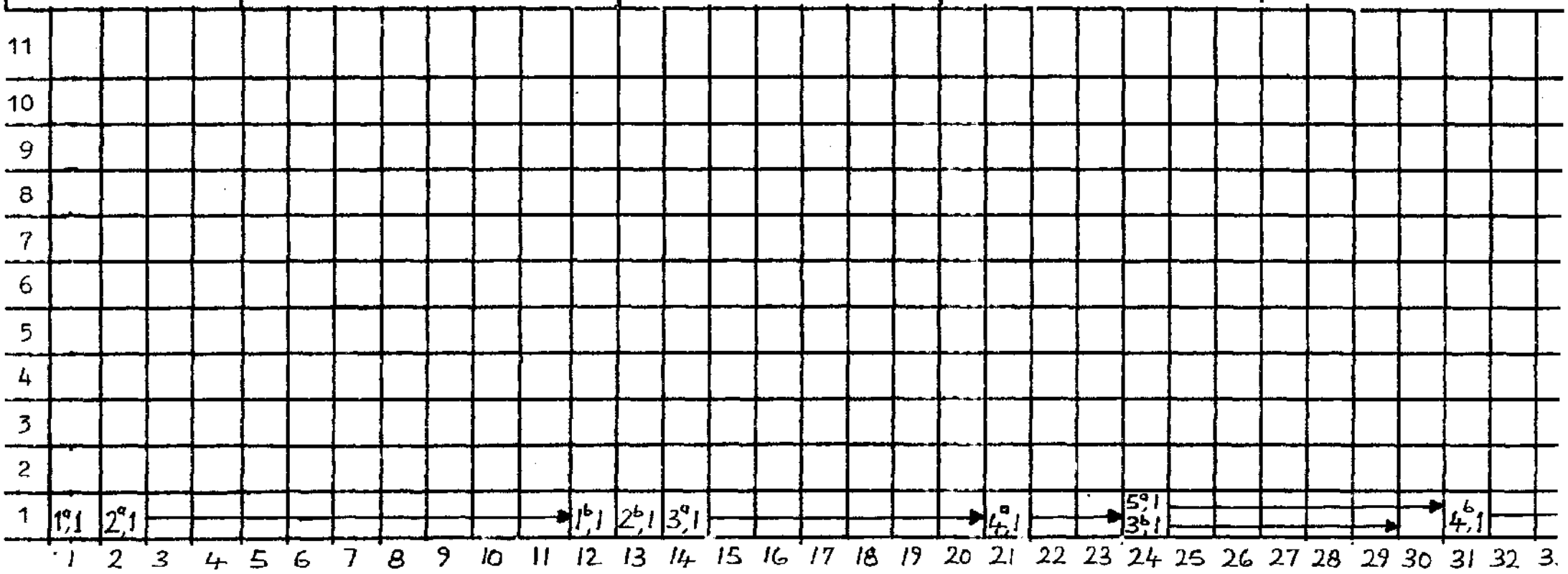


S. 4:13 A matrix organization approach structure showing the supporting relationship between the master team and 16 work squads.

The master team is made up of the general contractor and his project coordinators.

Table of work squads and M.O.A.M.

1 - Setting out work squad				
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt lay



Time phases

(Fig. 4.14)

LEGEND: ——► This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. —— Matrix Organization Approach model.

Figure 4.14 is a matrix organization approach model showing the logical sequence and inter-relationship of work tasks and their respective work squads in location 1 and with respect to their time phases.

This starts with work squad 1^a to 2^a, 1^b, 2^b, 3^a, 4^a, 3^b, and 5^a to 4^b which ends in time phase 33.

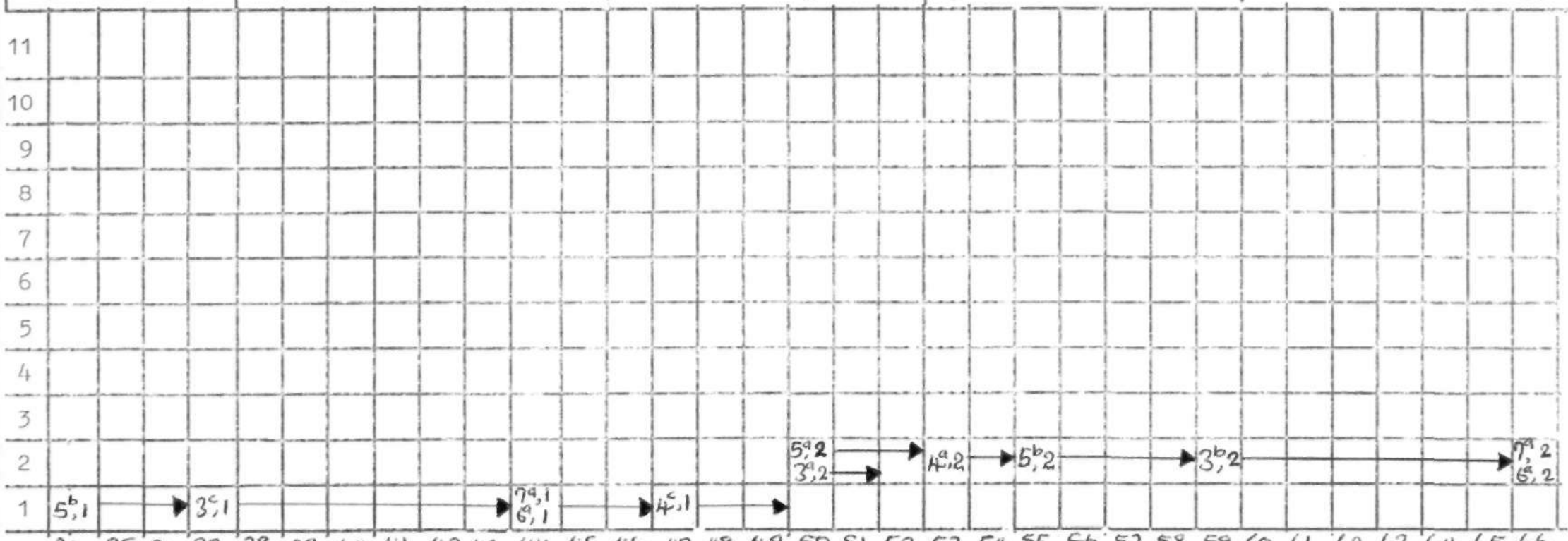
The task type corresponding to work squad 1, 2, 3, 4, 5 etc. are in the table of work squads in the figure. See 4.2.2 on page 76 for a detailed explanation of the lettering, e.g. 1^a , 1^b etc. used here. Also consult item 4.3 page 82 for the methodology.

The arrows denote the continuation and ending of work task by one or more work squads.

The limit of work contents will be as specified in the drawings and contract documents. A skeletal idea is listed in pages 120 to 125.

Table of work squads and M.O.A.M.

1 - Setting out work squad				
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt layer



Time phases (Fig. 4.15)

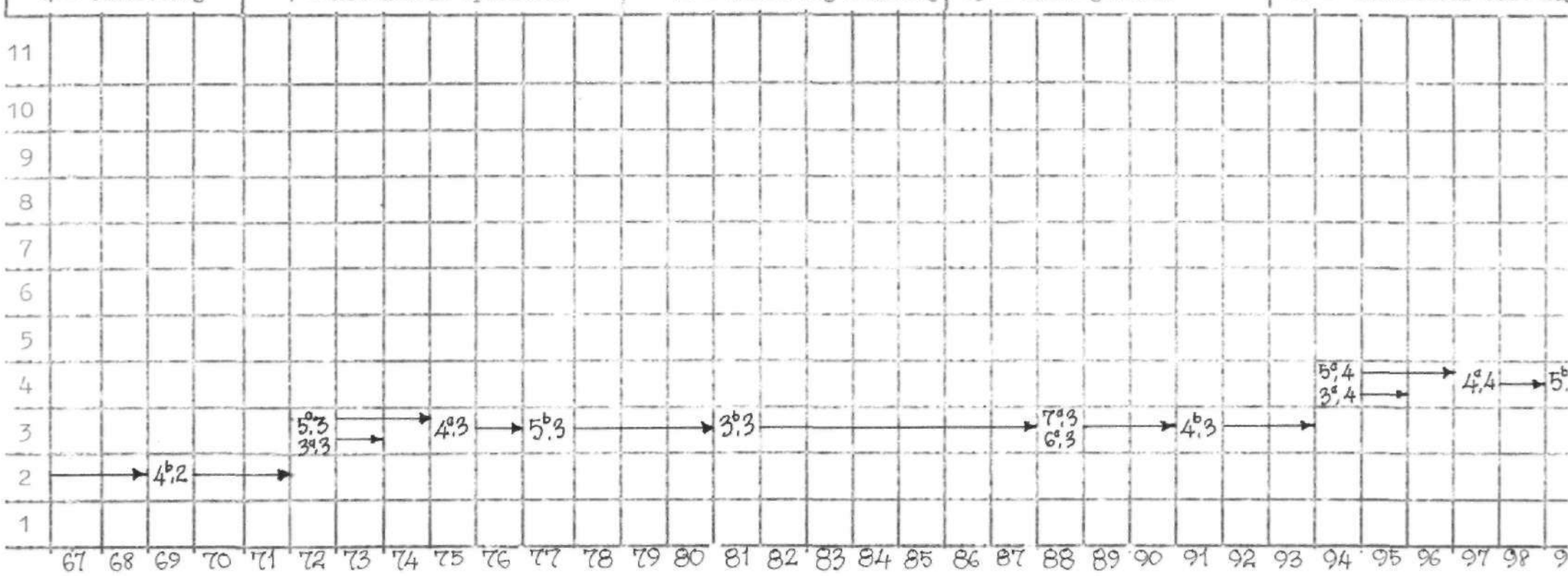
LEGEND: ⟶ This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

Figure 4.15 is a continuation of figure 4.14. It shows the continuation of work sequence in location 1 to the completion of basement frame construction at time phase 49, and the beginning of frame construction in location 2 at time phase 50, by work squads 3^a and 5^a acting simultaneously to some extent. Operations in location 2 on frame construction continues, up to time phase 71 in figure 4.16

Table of work squads and M.O.A.M.

1 - Setting out work squad				
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt la



Time phases (Fig. 4.16)

LEGEND: This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

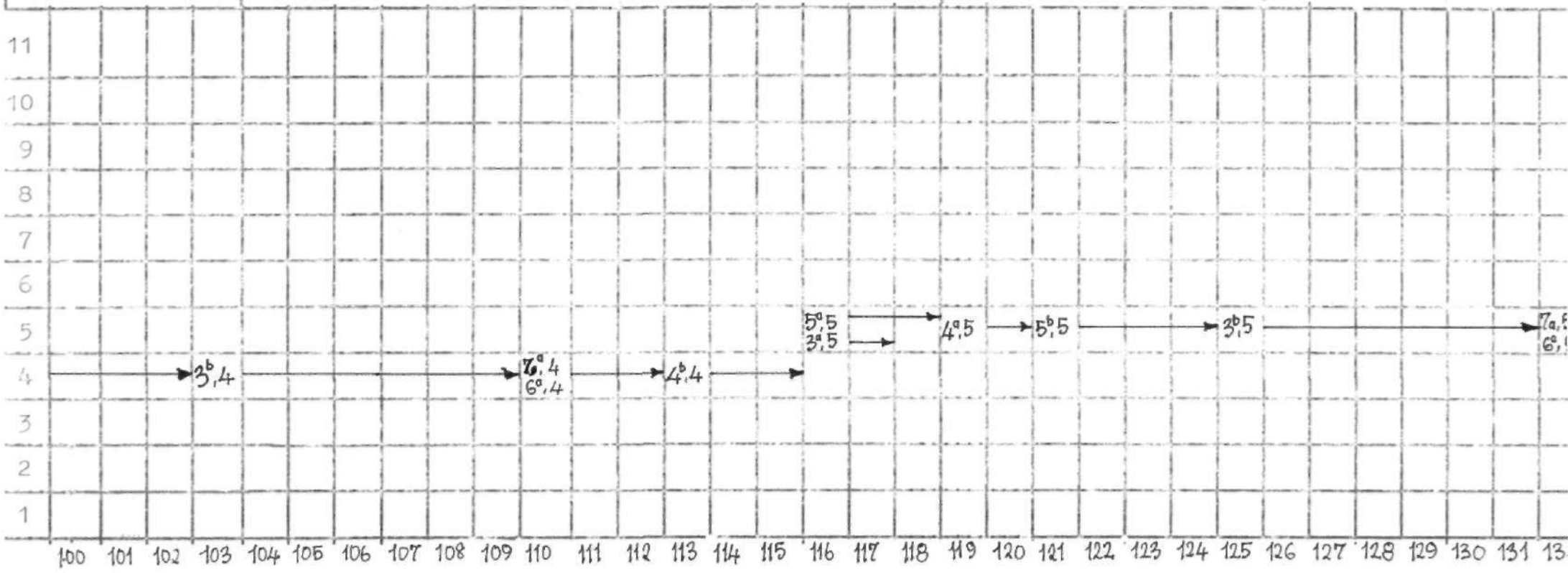
Figure 4.16 is a continuation of figure 4.15. It shows the termination of frame construction in location 2 at time phase 71 by work squad 4^b. Shown also is the initiation of frame construction by work squads 3^a and 5^a at time phase 72 to its termination at time phase 93 by work squad 4^b again.

At time phase 94 frame construction at location 4 is initiated. This process of frame construction for the 9-storey building is continued up to location 10 and terminates at time phase 247 in figure 4.21.

Thus, having a glance at figure 4.14 to 4.21, the reader will observe that as from location 2, the same type and number of work packages on frame construction repeats itself throughout the other locations up to location 10.

Table of work squads and M.O.A.M.

1 - Setting out work squad				
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bituminous felt lay



Time phases

(Fig. 4.17)

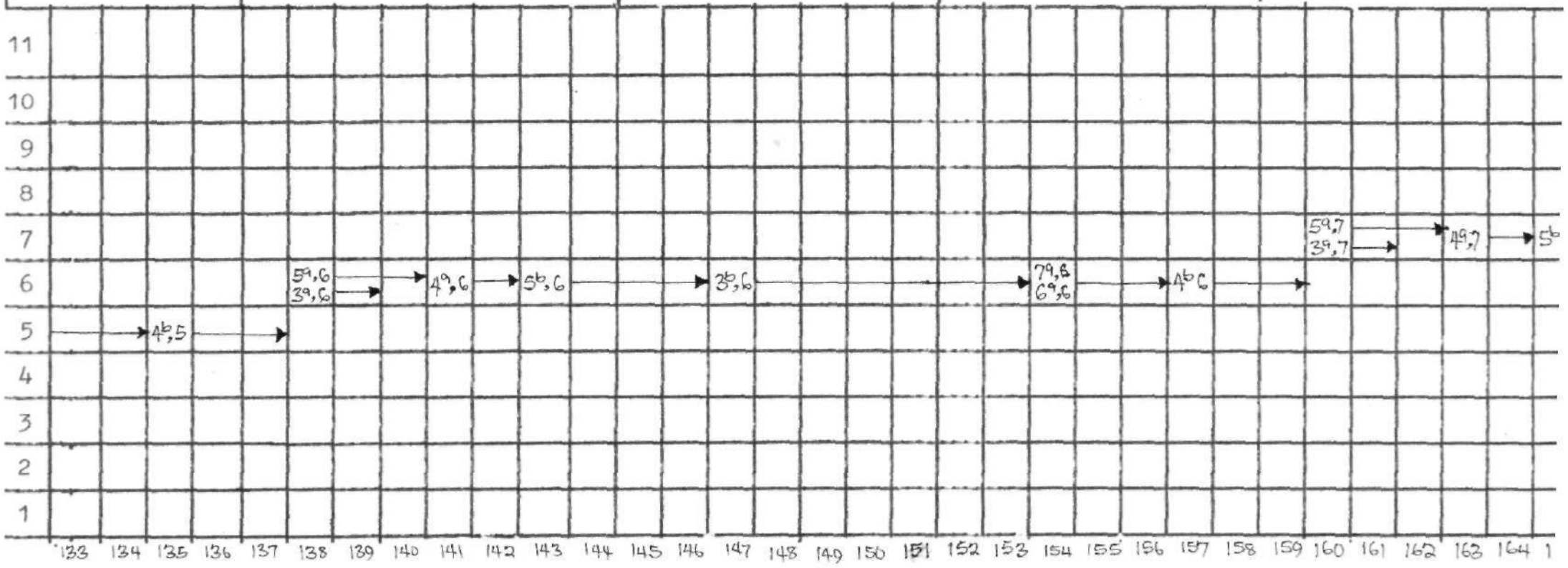
LEGEND: ⟶ This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

Figures 4.17 to 4.19 simply show the repetition of the frame construction. This is contained in the explanation of figure 4.16.

Table of work squads and M.O.A.M.

1 - Setting out work squad			
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt lay



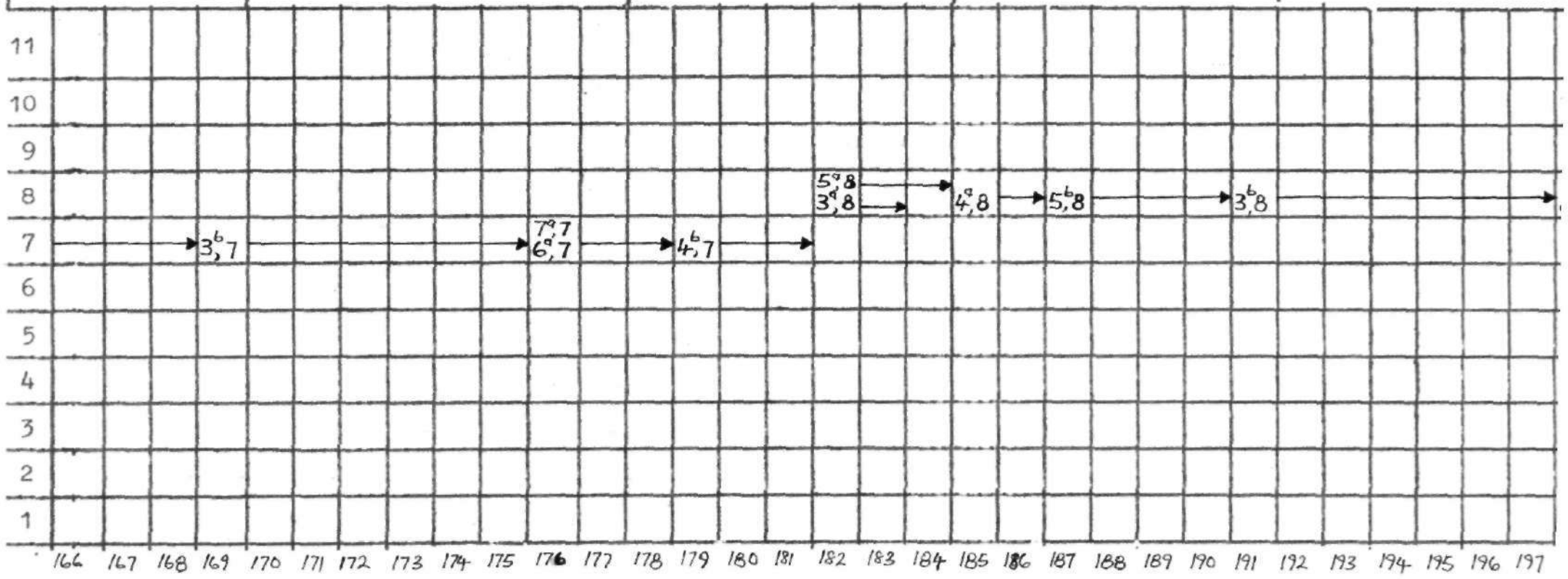
Time phases (Fig. 4.18)

LEGEND: ⟶ This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

Table of work squads and M.O.A.M.

1 - Setting out work squad			
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt 1



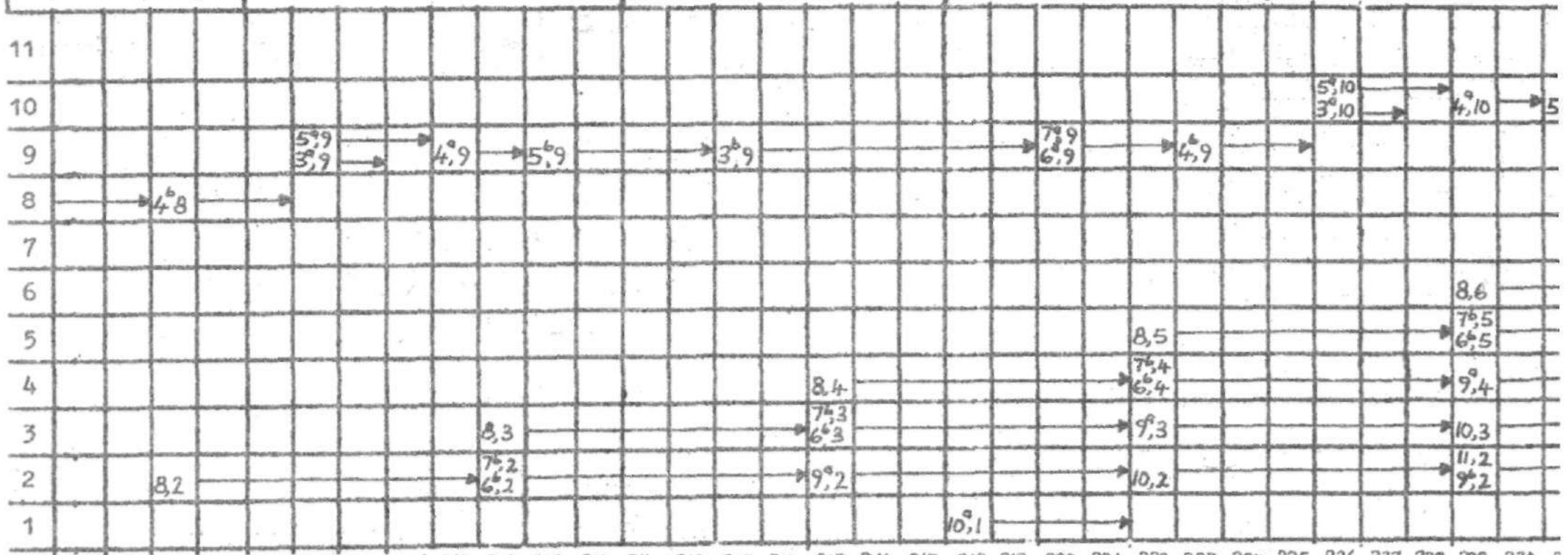
Time phases (Fig. 4.19)

LEGEND: ⟶ This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

Table of work squads and M.O.A.M.

1 - Setting out work squad				
2 - Excavation	5 - Form work & Seaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt le



Time phases (Fig. 4.20)

LEGEND: ——→ This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

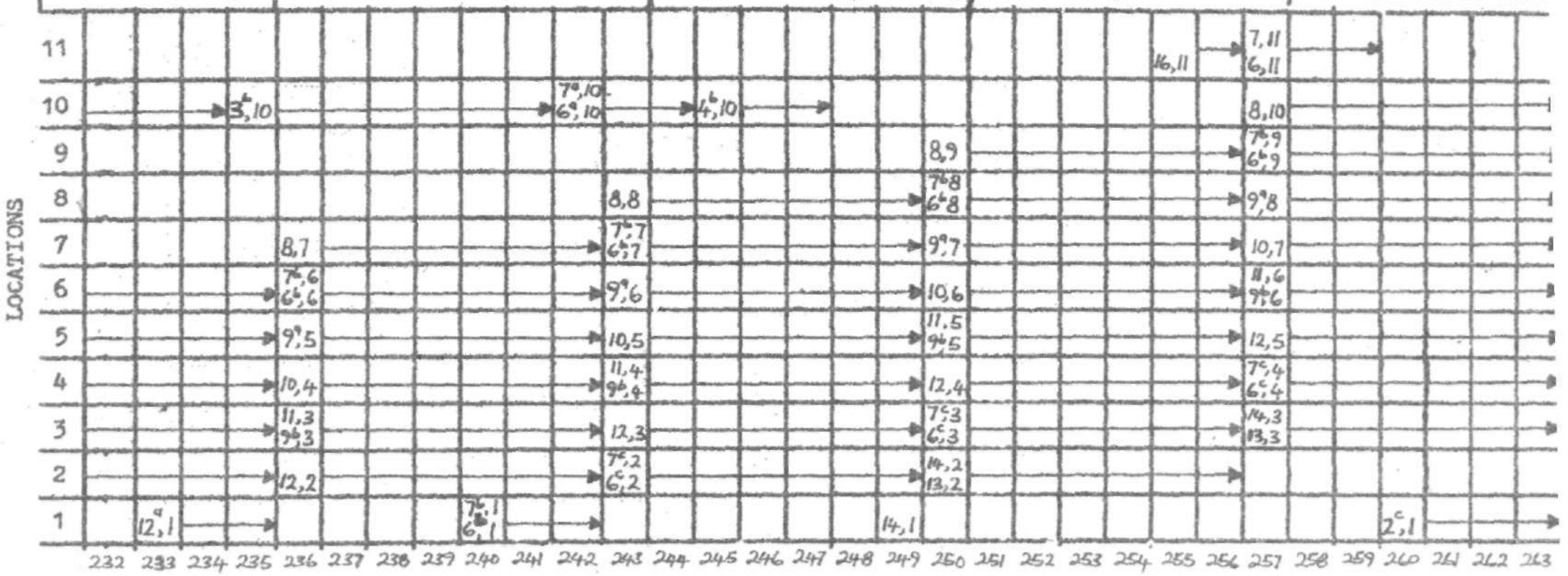
Figure 4.20 shows the logical sequence of work tasks concerning frame construction in location 8, 9 and 10. This has been described earlier in the explanation for figure 4.16.

Shown also is the initiation of cladding, partitioning and finishing operations in location 2 at time phase 201, in location 3 at time phase 208, in location 4 at time phase 215 up to location 6 at time phase 229. These operation continue till their terminations in other figures, e.g. figure 4.21 etc.

Finishing-operations starts in location 1 at time phase 218. With breaks here and there due to planning logic, the operation continue and terminates at time phase 249 in figure 4.21.

Table of work squads and M.O.A.M.

1 - Setting out work squad			
2 - Excavation	5 - Form work & Seaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car par
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt



Time phases (Fig. 4.21)

LEGEND: ——» This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

Figure 4.21 shows a mixture of frame construction; cladding, partitioning and finishing operations; and finally external operations.

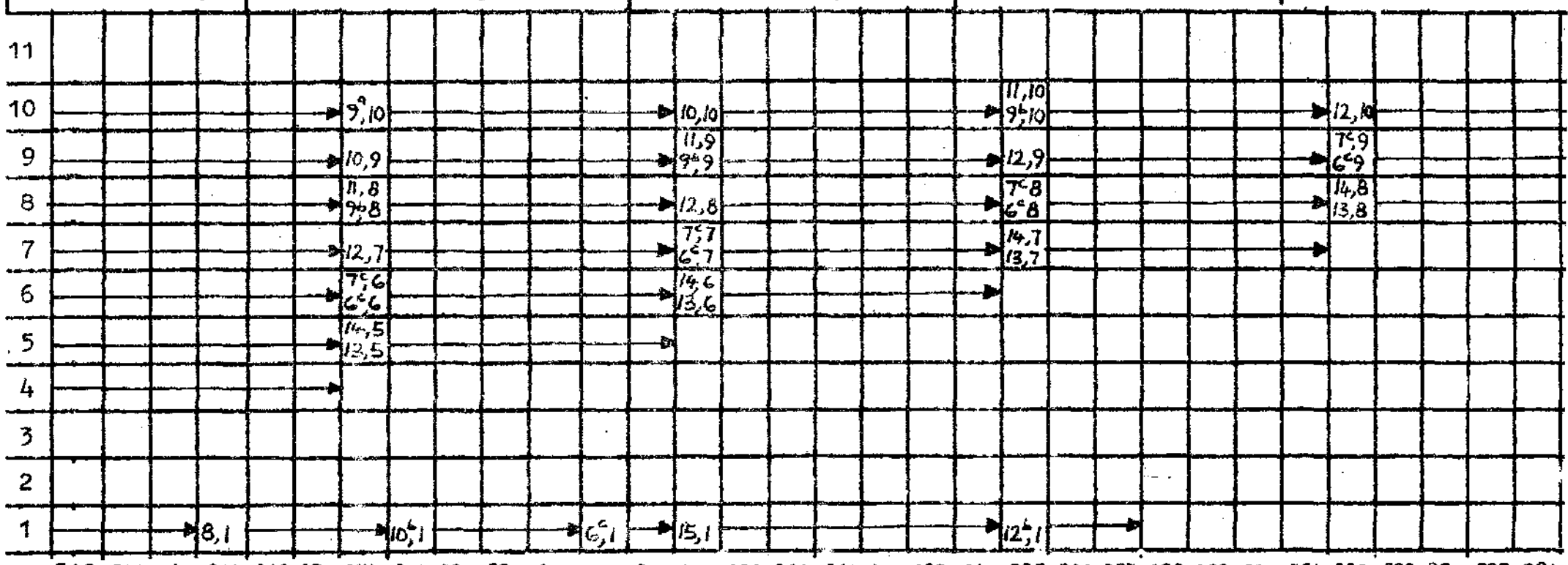
The frame construction terminates at time phase 247 and there is a break of 7 days to allow the concrete floor to mature before further operations on it. On time phase 255 bitumenous felt laying operations is started by work squad 16 on location 11. This is followed by work squads 6 and 7 which terminates operations on time phase 257.

Cladding, partitioning and finishing operations in locations 1 to 10 are still in continuation except for locations 1, 2 and 3 which also witness terminations at time phases 249, 256 and 263 respectively.

External works also starts at time phase 260 in location 1. This continues and terminates at time phase 287 in figure 4.22.

Table of work squads and M.O.A.M.

1 - Setting out work squad				
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt l



Time phases (Fig. 4.22)

LEGEND: ——▸ This arrow denotes the continuation and ending of work task by one or more work squads.

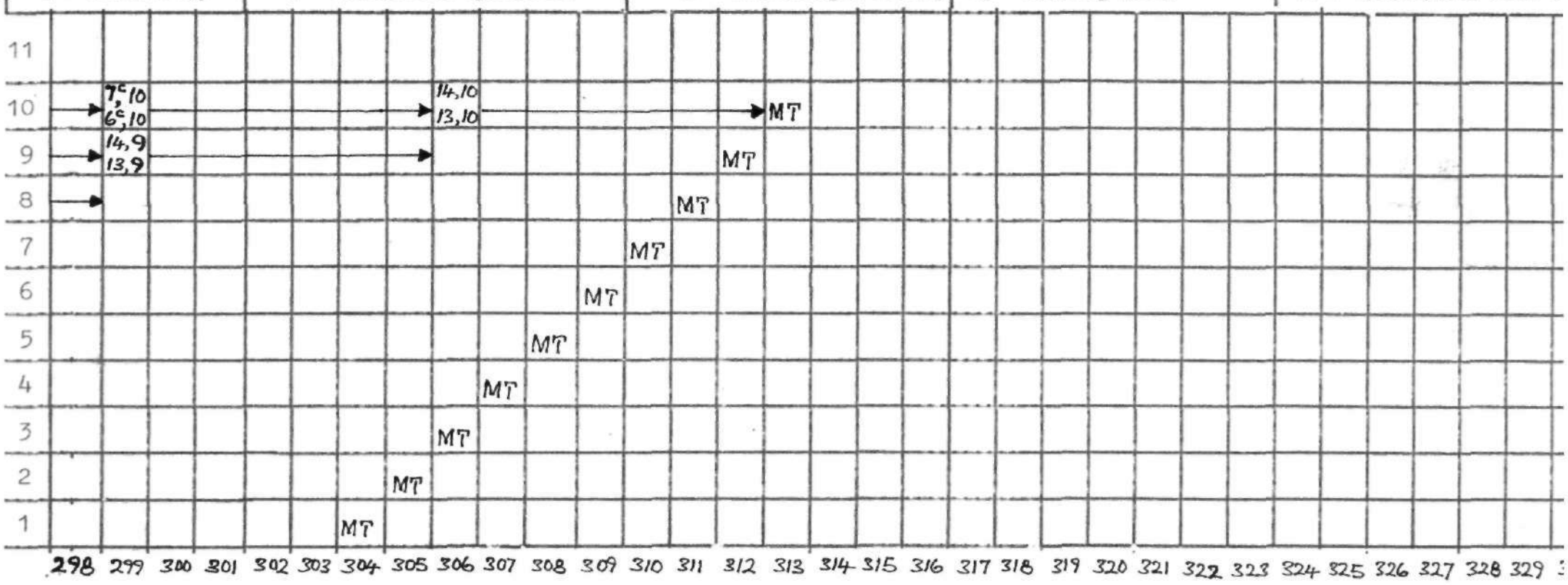
M.O.A.M. Matrix Organization Approach model.

Figure 4.22 shows the continuation of cladding, partitioning and finishing operations on locations 8, 9 and 10. It shows the termination in this regard on locations 4, 5, 6 and 7, at time phases 270, 277 and 284 respectively.

Shown also is the continuation and termination of external works, at time phase 287.

Table of work squads and M.O.A.M.

1 - Setting out work squad				
2 - Excavation	5 - Form work & Scaffolding	8 - Blockwork	11 - Ceiling operations	14 - curtain holders and rails
3 - Steel fixing	6 - Electrical operations	9 - Door and window	12 - Painting works	15 - Road and Car park
4 - Concreting	7 - Mechanical operation	10 - Rendering & Tiling	13 - Glazing works	16 - Bitumenous felt l



Time phases

(Fig. 4.23)

LEGEND: ⟶ This arrow denotes the continuation and ending of work task by one or more work squads.

M.O.A.M. Matrix Organization Approach model.

Figure 4.23 shows the termination of cladding, partitioning and finishing operations on locations 8, 9 and 10 at time phases 298, 305 and 312 respectively.

Shown also are continuous flow general cleaning operations in all the locations by the master team. This starts at time phase 304 in location 1 to time phase 313 in location 10. Thus, the completion of the project at this time phase.

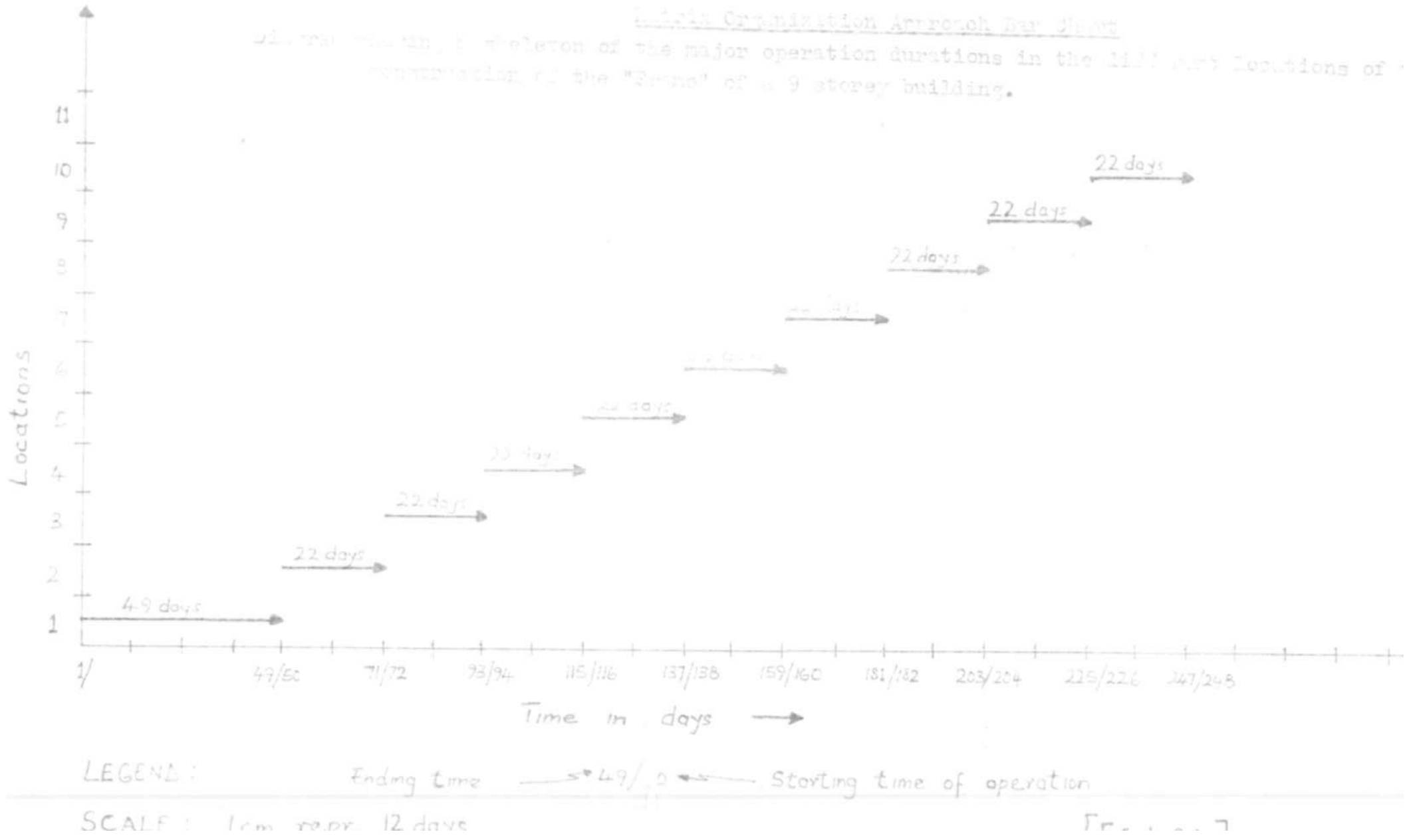

Matrix Organization Approach Bar Chart
Diagram showing the skeleton of the major operation durations in the different locations of the construction of the "Frame" of a 9 storey building.
Locations
1
2
3
4
5
6
7
8
9
10
11
49 days
22 days
22 days
22 days
22 days
22 days
22 days
22 days
22 days
1/
49/50
71/72
93/94
115/116
137/138
159/160
181/182
203/204
225/226
247/248
Time in days
LEGEND :
Ending time
49/50
Starting time of operation
SCALE : 1cm repr. 12 days

Figure 4.24 is a Matrix Mrganization Approach Bar Chart showing a skeleton of the major operation durations in the different locations of the construction of the "Frame" of the 9-storey building. As shown in the diagram in location 1; 49 days will be spent and from location 2 to location 10; 22 days each will be spent.

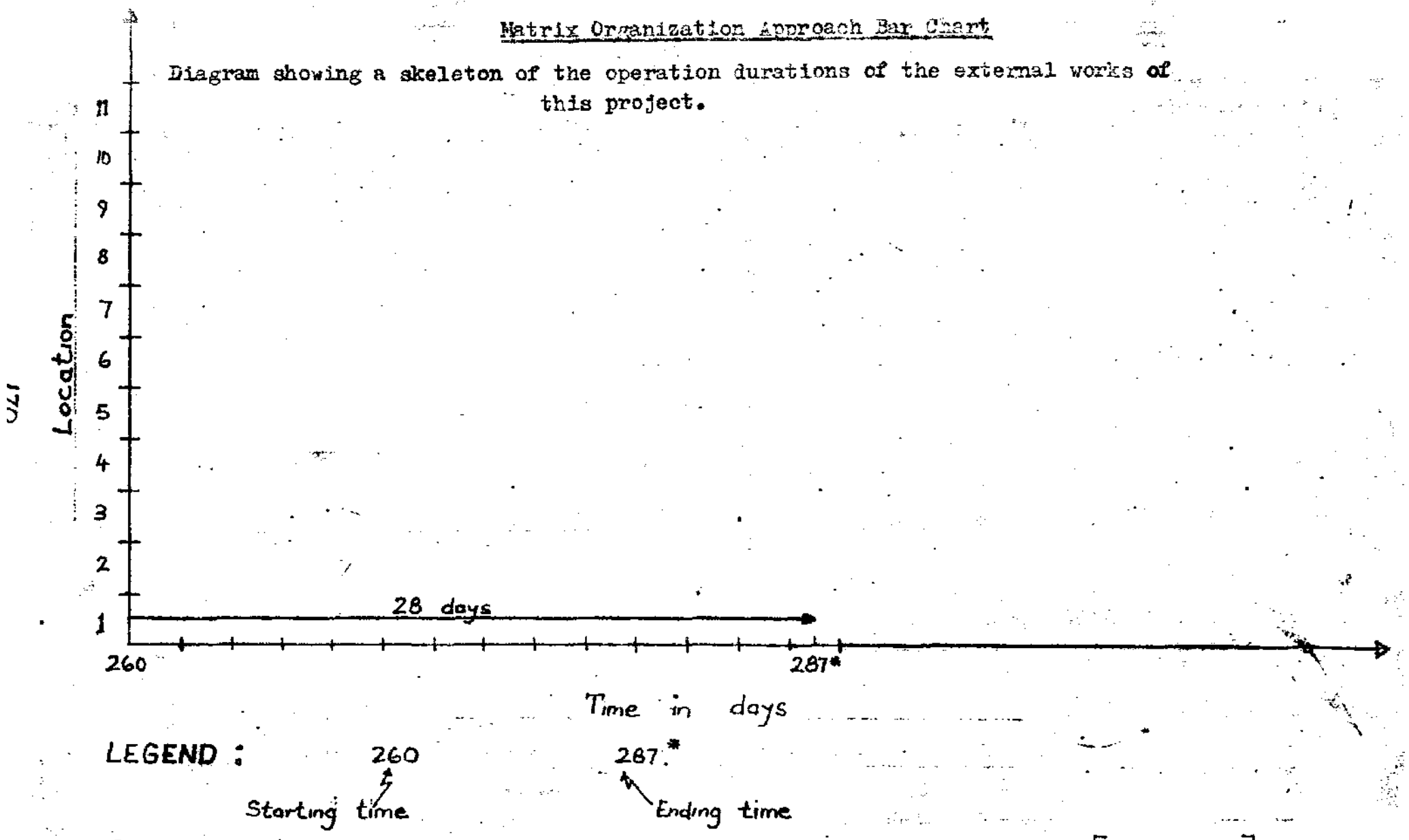
S^OI^D^O~7

Figure 4.25 is a Matrix Organization Approach Bar Chart showing a skeleton of the major operation durations of the formation works of the building in the different locations.

As indicated in the diagram in location 1; 4, 3, 3 and 1 day will be spent on Rendering, Painting, Electrical and mechanical works, and fixing of rails respectively. From location 2 to location 10; 56 days each will be spent on formation works. In location 11; 5 days will be spent.

Matrix Organization Approach Bar Chart

Diagram showing a skeleton of the operation durations of the external works of this project.



LEGEND : 260 — Starting time ; 287.* — Ending time

SCALE : 1 cm repr. 2 days

[Fig. 4-26]

Figure 4.26 is a Matrix Organization Approach Bar Chart showing a skeleton of the operation durations of the external work of the project.

As indicated in the diagram, 28 days will be spent on external works.

CHAPTER 5

5.0. CONCLUSION

5.1. Summary:

Investigations carried out indicate that the existing construction planning models, assume a central control over the resources to be allocated and levelled. This refers in particular to the bar chart, critical path method, Program evaluation and review technique, and the line of balance models.

We have shown in this work that this approach has contributed in no small measure to the low productivity, poor job performance, poor quality of product and low precision in construction works presently under-taken.

This central control approach over resources as we have indicated could exist in job shop scheduling in a factory under single ownership or single objective, but not in a construction project, which is dynamic and unpredictable.

A general contractor could manage a construction project but he should do that through the array of subcontractors who control the resources. There could be a

few or many subcontractors and each is trying to allocate and level his resources across a few or many projects simultaneously.

Matrix Organization Approach Model as we have shown provides the format for the management of the various subconstractors in a construction project.

It clearly attempts to obtain maximum technology, high productivity, maximum performance, high quality of product and high precision in construction in a cost effective manner and within time constraint.

This matrix model is particularly useful in housing estate construction with similar units and high rise buildings because of the repetition of work tasks which propagates continuous work flows of work squads.

This in itself enables work flow study through the use of the learning curve and the queuing theory concept.

5.2. Recommendations for further research:

We would recommend further research on this model in the following directions:

(a) The degree of feasibility of the application of this model, considering overall cost, to simple housing construction other than housing estates and high rise buildings. This is with the view to enable wide use of this model.

(b) The possibility of the application of quantitative methods, in determining the sequence in which all the work squads will pass through the different locations. This is in order to enable optimality in the application of this model.

(c) The most feasible way to handle the payments of work squads in relation to their work flows. This is to enhance cash flows and smooth execution.

(d) Linkage with data processing in order to equip the main contractor to be more able to cope with any disruption in plan. It is important to realise the fact that all work tasks are critical with this model.

(e) Further simplification of model, if possible, in order to enhance further ease in application.

BIBLIOGRAPHY

1. Adrian, J. J., Business practices for construction management, Elsevier, New York, 1976.

2. [illegible], H. N., Construction performance control by networks J. Wiley, New York, 1976.

3. Antill, J. M., and Woodhead, R. W., Critical path method in construction practice, John Wiley & Sons, Inc., New York, 1970.

4. Ashley, D. B., Use of simulation in crew Balancing and resources allocation for multiple unit housing construction, International Association for Housing Science Conference, Dharan, Saudi Arabia, December, 1978.

5. Battersby, A., Network analysis for planning and scheduling, third edition, MacMillan Company, London, England, 1970.

6. Bennett, J., Operational planning, chartered surveyor building and quantity surveying quarterly, London, England, 1978.

7. Birrell, G. S., A construction industry which is responsive to the demands of society - An effective target model for developing nations, International Association for Housing Science Conference, Dharan, Saudi Arabia, December, 1978.

8. Birrell, G. S., Construction planning - beyond the critical path, Journal of the construction division, A.S.C.E., Vol. 106, No. C03, September, 1980, pp. 389 - 407.

9. Birrell, G. S., Data processing for building control - An integrated concept, University of Edinburgh, Scotland, 1966.

10. Birrell, G. S., More efficient housing production - some lessons from the factory, presented at the 1967 third International Symposium on lower cost housing problems, International Association for Housing Science, held at Montreal, Canada.

11. Birrell, G. S., QUE-CON^2-Queuing theory networks for construction control and planning, presented at the May 1973, International Association for Housing Science Conference, held at Detroit, Mich.

12. Bonny, J. B., and Frein, J. P., Handbook of construction management and organization, Van Nostrand Reinhold Company, 1973.

13. Bowley. Mariam, British building industry; four studies in response and resistance to change, University press, Cambridge, 1966.

14. Burgess, R. A., et al The construction industry handbook, second edition, Lancaster, M.T.P. construction, 1973.

15. Calvert, R. E., Introduction to building management, third edition, Butterworth, London, 1970.

16. Carson, G. B., Production handbook, second edition, Ronald press, New York, 1967.

17. Chironis, N. P., Management guide for engineers and technical administrators, McGraw-Hill, New York, 1975.

18. Clough. R. H., Construction contracting, third edition, J. Wiley, New York, 1975.

19. Clough. R. H., Construction project management, Wiley interscience, New York, 1972.

20. Clough, R. H., and Sears, G. A., Construction project management, second edition, Wiley interscience, New York, 1979.

21. Conference of the Nigerian Economic Society, "The construction industry in Nigeria", Ibadan, Nigeria, 1974.

22. Deatherage, George, E., Construction Company organization and management, McGraw-Hill, New York, 1964.

23. Drucker, P. F., The practice of management, Heinemann, London, 1975.

24. Eckles, R. W., Carmichael, R. L. and Sarchet, B. R., Supervisory management, second edition, John Wiley & Sons, New York, 1981.

25. Fisk, J. C., Contractor/subcontractor relationships - site management information service, No. 71, Autumn, 1977.

26. Goldhaber, S., Jha C. K., Macedo, M. C. Jr., Construction management principles and practice, J. Wiley, New York, 1977

27. Haimann, T. and Scott, W. G., Management in the modern organization, second edition, Houghton Mifflin, Boston, 1974.

28. Halpin, D. W., and Woodhead, R. W., Construction management, J. Wiley, New York, 1980.

29. Hampton, D. R., Modern management ideas and issues, second edition, Prentice Hall of India. New Delhi, 1979.

30. Harris, F., and Mc.Caffer, R., Modern construction management, Crosby Lock wood Staples, London, 1977.

31. Hillebrandt, P. M., Small firms in the construction industry MacMillan, H.M.S.O., London, 1971.

32. Hollins, Raymond, C., Production and planning applied to building, published by G. Godwin for "The Builder", London, 1962.

33. Horowitz, S. Jr., Job-site management - An exercise in concurrency, HRH construction corporation, N. Y. (supporting paper to Turner, H.S., "construction site management", presented at the 1968 fourth CIB Congress).

34. Hugsted, R., The influence of repetition on time consumption of site operations, presented at the 1965, third CIB Congress.

35. Journal of the construction division, American Society of Civil Engineers, March 1956 - September, 1981.

36. Karger, D. W., and Murdick, R. G. Managing engineering and research, third edition, Industial press, 1980.

37. Kavanagh. T. C., Muller, F., O'Brien, J. J., Construction management - A professional approach, McGraw-Hill, New York, 1978.

38. Leon, George, The economics and management of system construction, Longman group, London, 1971.

39. Lewis, B., Management for the future, McGraw-Hill, New York, 1978.

40. Mali, P., Management handbook; operating guide lines, techniques and practices, John Wiley & Sons, New York, 1981.

41. Marquis, D. G., A project team + PERT = Success or Does it? "Innovation Number five" 1969, pp. 26 - 33.

42. Marquis, D. G. and Straight, D. M., Organizational factors in project performance, Washington D.C., National Aeronautics and space Administration, July, 25, 1965.

43. O'Brien, J. J., C.P.M. in construction management, second edition, McGraw-Hill, New York, 1971.

44. Oxley, R., and Poskitt, J., Management techniques applied to the construction industry, second edition, Crosby Lockwood & Son, London, 1971.

45. Palm, Y., The effect of repetition on building operations, presented at the 1965 third CIB Congress.

46. Peer, S., Network Analysis and construction planning, Journal of the Construction Division, A.S.C.E., Vol. 100, No. CO3, proc. paper 10792, Sept., 1974, pp. 203 - 210.

47. Peurifoy, R. L., Construction planning, equipment, and methods, McGraw-Hill, New York, 1979.

48. Pilcher, Roy, Principles of construction Management, second edition, McGraw-Hill, London, 1976.

49. "RAMPS - Users guide" CEIR Incorporated, Arlington, Va, 1962.

50. Rist, John, Laing, P. T., "Cascaded charts in construction presented at the 1972 INTERNET Conference, held at Stockholm, Sweden.

51. Ross, J. E., Managing productivity, Reston publishing, Reston, Virginia, 1977.

52. Sargeaunt, M. J., Operational research for management, Heinemann, London, 1965.

53. Simon, H. A., New science of management decision, Harper and Row publishers, Inc., New York, 1960.

54. Stillman, W. J., Construction practice for project managers and superintendents, Reston publishers, Reston, Virginia, 1978.

55. Teriba, O., and Bayode, M. O., Industrial development in Nigeria, Ibadan University Press, Ibadan, Nigeria, 1977.

56. Thompson, F. M. L., Chartered surveyors, the Growth of a profession, Routledge, Kegan Paul, London, England, 1968, Chapter 4.

57. Ugander, C., Construction site planning presented to the 1968, fourth CIB Congress.

58. United Nations, Industrial Development Organization, Industrialization of developing countries; problems and prospects. Construction Industry; based on the proceedings of the international symposium on industrial development, (Athens, Nov. - Dec., 1967) United Nations, New York, 1969.

59. Ural, O., Construction of lower-cost housing, J. Wiley, New York, 1980.

60. Volpe, Peter, S., Construction management practice, Wiley interscience, New York, 1972.

61. Wass, Alonzo, Construction management and contracting, Eagle Wood Cliffs, N.J., Prentice-Hall, 1972.

62. West African Technical Review, September 1976 - September 1982.

63. Wiest, J. D., Heuristic Programs for decision making, Harvard Business Review, Setp./Oct., 1966.

64. Wiest, J. D., Scheduling program for allocating resources, management science, Feb., 1967.

65. Wilson, R.M.S., Cost Control hand-book, Gower press hand-book, Great Britain, 1975.

APPENDIX A

Examples of types of sub-contractors presently in Nigeria. (Traditional classification)

1. Specialist sub-contractors:
   - (a) Asphalt felt roofing
   - (b) Patent floor covering
   - (c) Reinforced concrete floor units
   - (d) Precast concrete floor units
   - (e) Air conditioning and heating
   - (f) Suspended ceilings
   - (g) Curtain walling
   - (h) Mechanical services

2. Trade sub-contractors:
   - (a) *Electrician
   - (b) *Plumbing
   - (c) Glazing
   - (d) Plastering
   - (e) Roofing tiling
   - (f) Wall tiling
   - (g) Painting and decorating
   - (h) Scaffolding
   - (i) Form work

* Could give design service.

3. Labour only sub-contractors:

(a) Ground work

(b) Brick work

(c) Carpentry

APPENDIX B

Examples of *Specialist-Sub-contractor that is compatible with Matrix Organization Approach.

(a) Setting-out Subcontractor (e.g. land surveyors)
(b) Excavation "
(c) Steel fixing "
(d) Concreting "
(e) Form work/Scaffolding Subcontractor (e.g. land surveyors)
(f) Electrical Services "
(g) Mechanical Services "
(h) Block work "
(i) Wall and floor rendering "
(j) Carpentry/Joinery works "
(k) Suspended ceiling "
(l) Painting and decorating "
(m) Glazing works "
(n) Asphalt felt roofing " etc.

*Specialist-Subcontractors here covers any subcontractor, that is a specialist in a work task.

APPENDIX C

Existing Construction Planning Models:

(a) Bar charts.

(b) Line of balance models.

(c) Multi-activity and crew balance charts.

(d) Critical Path Method.

(e) Program Evaluation and Research Technique.

(f) Queuing models.

(g) Simulation models (e.g. *Cyclones, etc.)

*Cyclones mean cyclic operations network. This is both a modeling methodology and simulation language developed by Halpin (also called Halpin's system).

APPENDIX D

QUESTIONAIRES ON CONSTRUCTION PLANNING

NAME OF FIRM: .....

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SITES: .....

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YEARS OF EXPERIENCE:

.....

.....

RESPONDENT: .....

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AREAS OF CONCENTRATION IN THE COUNTRY:

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QUESTION 1: What method of planning do you apply in planning and controlling your projects?

ANSWER: .....

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SECTION A (If C.P.M./PERT is applied)

QUESTION 1: Why do you use C.P.M./PERT in planning and controlling your projects?

ANSWER: .....

.....

.....

QUESTION 2: Have you tried any other method before?

ANSWER: .....

.....

.....

QUESTION 3: How do you find it in terms of feasibility and applicability?

ANSWER: .....

.....

.....

QUESTION 4: Do you think it's the best method or are you using it because it's the most recent?

ANSWER: .....

.....

.....

QUESTION 5: Have you been obtaining satisfactory results from the application of C.P.M./PERT?

ANSWER: .....

.....

.....

.....

SECTION A (If C.P.M./PERT is applied) Continued.

QUESTION 6: Do your lientenants/subordinates get along with you (understand you) when C.P.M./PERT is applied?

ANSWER: .....

.....

.....

QUESTION 7: Is there any particular advantage in applying C.P.M./PERT with respect to minimizing cost and minimizing overall project duration - (maximizing profits)?

ANSWER: .....

.....

.....

QUESTION 8: Having a critical look at the resources required to execute a project generally and the end product to be constructed, do you think that C.P.M./PERT model represents a real world solution to the essence of construction planning?

ANSWER: .....

.....

.....

QUESTION 9: Have you been keeping pace with recent reserches and developments in construction planning with respect to C.P.M./PERT?

ANSWER: .....

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SECTION A (If C.P.M./PERT is applied) Continued.

QUESTION 10: If yes, do you find them applicable to the conditions in Nigeria, now and in the near future?

ANSWER: .....

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QUESTION 11: Is there any contribution you have, to make C.P.M./PERT more applicable and simplified with respect to Nigeria?

ANSWER. .....

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QUESTION 12: Why is C.P.M./PERT not generally applied in Nigeria?

ANSWER: .....

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SECTION B (If Bar Chart is applied)

QUESTION 1: Why do you use Bar Chart in planning and controlling your projects?

ANSWER: .....

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QUESTION 2: Have you tried any other method before?

ANSWER: .....

.....

.....

QUESTIONS 3: How do you find it in terms of feasibility and applicability?

ANSWER: .....

.....

.....

QUESTION 4: Do you think it's the best method or are you using it because it is the one you know?

ANSWER: .....

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.....

QUESTION 5: Have you been obtaining satisfactory results from the application of Bar Chart?

ANSWER: .....

.....

.....

SECTION B (If Bar Chart is applied) continued.

QUESTION 6: Do your lieutenants/subordinates get along with you (understand you) when Bar Chart method is applied?

ANSWER: .....

.....

.....

QUESTION 7: Is there any particular advantage in applying Bar Chart method with respect to minimizing cost and minimizing overall project duration (maximizing profits)?

ANSWER: .....

.....

.....

QUESTION 8: Having a critical look at the resources required to execute a project generally, and the end product to be constructed, do you think that Bar Chart model represents a real world solution to the essence of construction planning?

ANSWER: .....

.....

.....

QUESTION 9: Is there any recent development in the Bar Chart method you know of?

ANSWER: .....

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SECTION B (If Bar Chart is applied) continued.

QUESTION 10: Is it applicable to the conditions in Nigeria now and in the near future?

ANSWER: .....

.....

.....

.....

QUESTION 11: Is there any contribution you have, to make Bar Chart method more applicable and feasible to the essence of construction planning with respect to Nigeria?

ANSWER: .....

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SECTION C (General)

QUESTION 1: Have you been keeping pace with recent researches and developments in construction planning and control of projects generally?

ANSWER: .....

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QUESTION 2: What method of planning and controlling building projects do you feel is best fit for Nigeria?

ANSWER: .....

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QUESTION 3: Reasons?

ANSWER: .....

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QUESTION 4: How do you find your nominated sub-contractors?

ANSWER: .....

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SECTION C (General) continued.

QUESTION 5: What about your own selected sub-contractors
e.g.: Labour only, sub-contractors
Trades sub-contractors and
Specialist sub-contractors,

How do you cope with them?

ANSWER: .....

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QUESTION 6: How is the productivity of the local labour here?

ANSWER: .....

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QUESTION 7: What are your suggestions towards Successful Construction Planning?

ANSWER: .....

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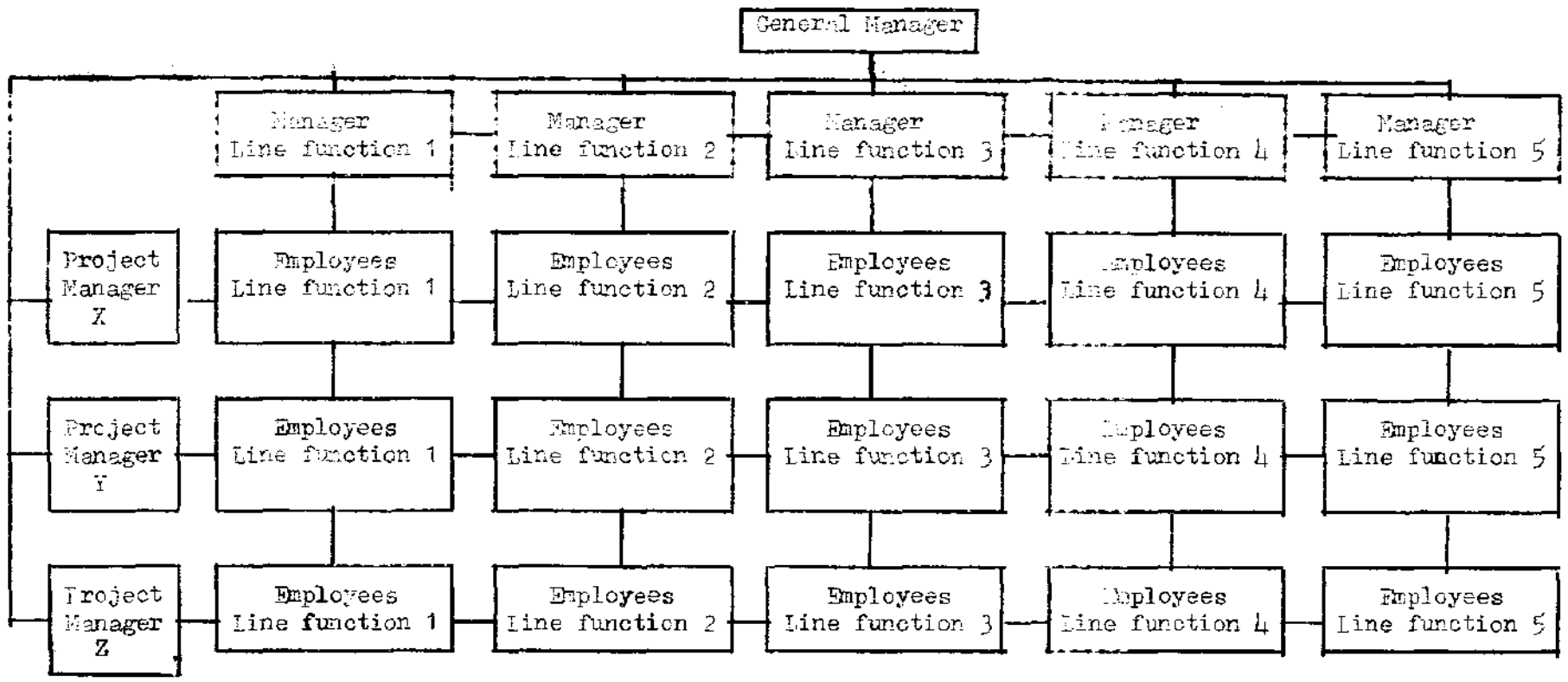

LEGEND: Line function = Work squad

Matrix project management is an attempt to obtain maximum technology and performance in a cost effective manner and within time and schedule constraints.

Appendix E - Pure Matrix Structure (Matrix Organization Approach Chart)