COST ANALYSIS FOR MULTISTOREYED RESIDENTIAL BUILDINGS-DELHI REGION

A DISSERTATION

Submitted in partial fulfilment of the requirements for the award of the degree of

MASTER OF ARCHITECTURE

By

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled, **"Cost Analysis for Multistoreyed Residential Buildings - Delhi Region"** in partial fulfilment of the requirement for the award of the **Degree of M. Arch.** submitted in the Department of Architecture of the University is an authentic record of my own work carried out during a period from August 1994 to January 1995 under the supervision of **Mrs. Rita Ahuja.**

The matter embodied in this thesis has not been submitted by me for the award of any other degree.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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CHAPTER 1

CHAPTER I - INTRODUCTION

1.1 BACKGROUND

Recent years have been a sharp rise in the nature and complexities in the basic fabric of the built environment, i.e., the buildings. The growing levels of urbanization and the fast pace of technological advancements coupled with the increased intricacies and complexities of the clients requirements has made designing much more than the mere whims of an artists fantasy. It today, demands imagination in tandem with hardcore technical knowhow on a realistic and practical basis.

The increase in the technicalities and disciplines in a building have further pushed up the cost of a building and hence the recent years have seen an increased attention being paid to the building cost and much emphasis being placed on the need for economy in design, accuracy in cost forecasting and effective control of cost while designing.

1.2 IDENTIFICATION OF THE PROBLEM

As mentioned the modern day pressures have engulfed the present day building practices. It has become absolutely essential now to maintain positive control over costs as design decision are made, such that the completed

schemes complies with the building owners cost requirements.

The architects needs to exercise control of building costs. For mainly three reasons the cost control become crucial :

(a) To give the client good value for his money.

(b) To achieve the required balance of expenditure between the different building parts.

(c) To keep expenditure within the amount allowed by the client.

For example -

* Single House

  The house owner has set requirements and budget and the architect has to do justice to both.

* Housing Estate :

  The builder has to provide adequate accommodation for a limited cost at the same time he must be able to offer the completed house at an attractive price in order to compete.

* Public Authority :

  Local authorities and other development authorities involve expenditure of public money and call for maximum attention to design efficiency.

* Commercial and Industrial :

  Funds for such a venture come from reserved funds or creation of new capital by issue of stocks and shares or through loans from banks or a finance company at high rates.

* Development Companies :

  Which wish to make buildings for investment or sale and hence the amount of money they expect in return minus their profit is the fixed sum available for the building costs.

1.3 SCOPE AND LIMITATIONS OF THE PROBLEM

Scope

In the past decade, New Delhi, the capital has witnessed an ever increasing influx of population which has overlayed its resources. The ever increasing demand of housing has resulted in developments of the suburban areas. The mammoth task could not be handled by the Government Agencies alone and thus entered the private developers and builders in the picture.

So today Delhi when approached from any direction welcomes you by the huge residential development on its outskirts, both low rise and high rise viz. Ghaziabad/Noida/ Gurgaon/Rohini. All these are developed either by the concerned development autorities or by a private builder.

Through this thesis which has picked up case studies in the New Delhi outskirts one developed by G.D.A. i.e., Ghaziabad Development Authority and the other a Co-operative Group Housing Scheme (C.G.H.S.), an attempt shall be made to work out crucial parameters to help practising architects, development authorities, private developers to understand cost distribution and method of reducing cost of their buildings without compromising on value by careful decisions made at the sketch design stage itself.

Limitations

From the wide range of building types, multistoreyed residential apartments have been selected as the analysis and of the various buildings systems and parameters identified only some shall be selected which shall be feasible to analyse within the given time frame. Also the dissertation shall only deal the construction costs for multistoreyed apartments for the analysis.

1.4 OBJECTIVES OF THE STUDY

With this background on present day housing situation and with a view of the associated problem, the importance and knowledge of cost analysis and control is established.

This dissertation shall not aim at studying low cost techniques and at the same time it does not recognise reduction of floor area or reduction in the quality of

material and finishes as means of cost control. These are incidental. The emphasis of the dissertation shall be to analyse with the help of a case study/case studies the cost distribution among the major building systems and their nature, so as to arrive at some logical conclusions. Some practical recommendations and guidelines have been given in last chapter of the disseration which can be adopted at the initial sketch scheme stage by the architect to maintain cost control.

Analysis of the case studies through individual assessment and by drawing comparisons shall concentrate on :

(i) To analyse the areas assigned to the various building functions and call attention to any excessive space allocation.

(ii) To analyse the impact of height floor to floor and total.

(iii) To analyse the ratio of square feet net to square feet grows.

(iv) To analyse the ratio of the area of the perimeter walls to the gross floor area of the building and analyse its impact on other costs.

(v) To analyse the quality and useful life of some of the building systems and examine possibilities of cost reduction which retaining values.

(vi) To identify the crucial parameters/building elements and their characteristics to enable a reasonably accurate cost estimate at the inception of the project.

CHAPTER 2

CHAPTER II - LITERATURE REVIEW

2.1 COST CONTROL IN MULTISTOREYED BUILDING DESIGN

2.1.1 Need for Cost Control

Sociological, economic and technological pressures of the present day are very different from those of the early nineteenth century and in consequence the structure and practices of the building industry have been under considerable strain. In particular, these modern pressures have made the control of building costs both more important and more difficult than hitherto.

1. The first is that as society is developing more rapidly than before, the pace of development in building is increasing.

2. The second pressure is that clients requirements are becoming more complicated.

3. The third pressure stems from client organisations being larger.

4. The fourth pressure stems from modern practice in design, where new techniques and materials are used.

2.1.2 Purpose of Cost Control

A cost control system has three purposes :

(a) To give the client good value for money.

(b) To achieve the required balance of expenditure between the various parts of the building.

(c) To keep expenditure within the amount allowed by the client.

2.1.3 Principles of Cost Control

Cost control belongs to a family of control systems based on three principles :

(a) There must be a frame of reference.

(b) There must be a method of checking.

(c) There must be a means of remedial action.

Having a frame of reference in a cost control system consists of two stages :

(a) Establishing a realistic first estimate.

(b) Planning how this estimate should be spent among the elements of the building.

2.2. COST STUDY FOR BUILDING ECONOMICS

Definition

Cost study sets out to analyse building costs in terms of the constituent elements.

2.2.1 Aims and Objectives of Cost Study

The aim of cost study can be summarized as follows :

(a) To reveal the distribution of costs between the constituent elements of the building,

(b) To relate the cost of any constituent element to its importance as a necessary part of the whole building,

(c) To compare the costs of the same element in different buildings,

(d) To consider if expenditure could have been differently allocated, resulting in a beeter building,

(e) To obtain cost data for use in planning other projects, and

(f) To ensure a prorper balance of quantity and quality within the appropriate cost limit.

2.2.2 Brief on Major Constitutents of Cost Study

Two aspects of cost study can be distinguished. Cost analysis, which is the examination of the cost of the projects already planned or built, for which bills of quantities are available, it is in the nature of a postmortem. Cost planning, which uses the information gained from cost analysis to maintain a surer control over costs on current projects, it is in the nature of a forecast.

♯ Cost Analysis

Cost analysis seeks to achieve aims, i.e. it should enable the design team to find out how much has been spent on each element of a building and to assess objectively where they have been relatively extravagent or unnecessarily economical and make value judgements on the balance of the design solution. This is particularly worthwhile if this exercise is carried out with the purpose of making use of this knowledge in planning current projects.

A cost analysis of a tender is a record showing the effectiveness of the cost control exercised throughout the pre-contract planning. If, throughout this stage, attention has been given to the cost of the design, no bills of reduction will be expected or needed. At tender, or course, it may be too late to adjust the elements which are really at fault, in which case, the reductions made usually involve an attack on the finishes and fittings and/or other amenities, resulting in an unsatisfactory building. It will be the aim of the design team to avoid this situation.

To prepare a cost analysis manually, the following documents are required :

(a) Fully priced bills of quantities, together with sub-bills or detailed estimates of any sums included in the bills as prime cost or provisional sums.

(b) Working drawings and specifications. These will be required to calculate the quantity factors listed and described in the standard form of Cost Analysis. They will also be required when certain items in the bills have to be apportioned to two or more different elements, and to identify items in the bills so that they can be assigned to the appropriate element, unless this has been catered for at the time of measuring the work.

 # Cost Planning

Cost planning is the term used to describe a method of allocating a pre-determined total sum of money between the elements of a building, using data from cost analysis, with the object of providing :

(a) a proper belance between the area provided and the cost per square meter,

(b) a proper balance of cost between the constituent elements.

By using the technique of setting cost targets for each of the elements at the formative stages of the work, i.e., outline proposals and scheme designs - the design team can feel confident from the outset about the ultimate quality and cost of the scheme.

Through the agency of the cost analysis the architect is in a good position to evaluate the past performance of his own and/or other peoples design, in terms of the specifications of the elemental parts and their costs, as well as the effectiveness of the total building and its cost.

Having a fixed sum of money to work with the architect will want to balance the allocation of money between the elements in a proportion which will allow him to achieve his design solution in accordance with the client's brief.

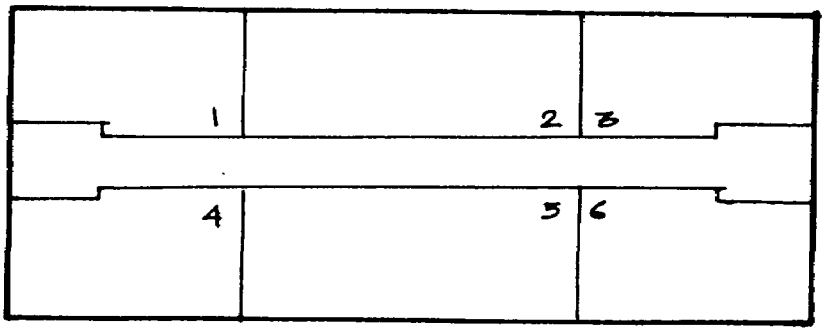
2.3 PARAMETERS OF BUILDING ECONOMICS

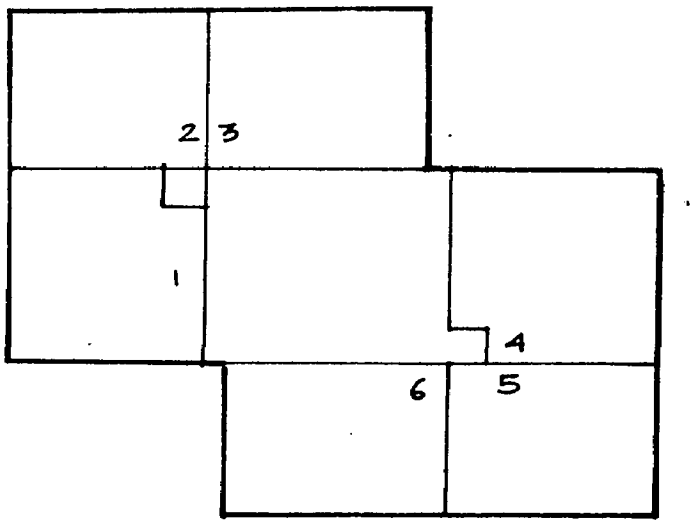
A plethora of factors govern building costs, e.g., shape of buildings, structural system standard of finish, site conditions. these factors are inter-related and it is not always easy to isolate the cost effect of one from the effect produced by others.

2.3.1 Design Factors

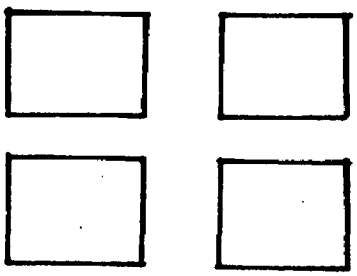
(A) Plan Shape

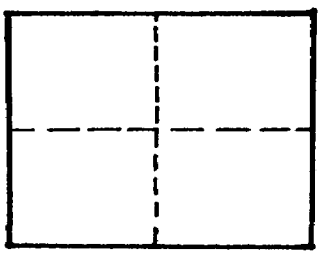
Aesthetic and functional requirements, aspect, shape and slope of site, density and byelaw requirements, structural system, services arrangements and cost combine to determine shape.

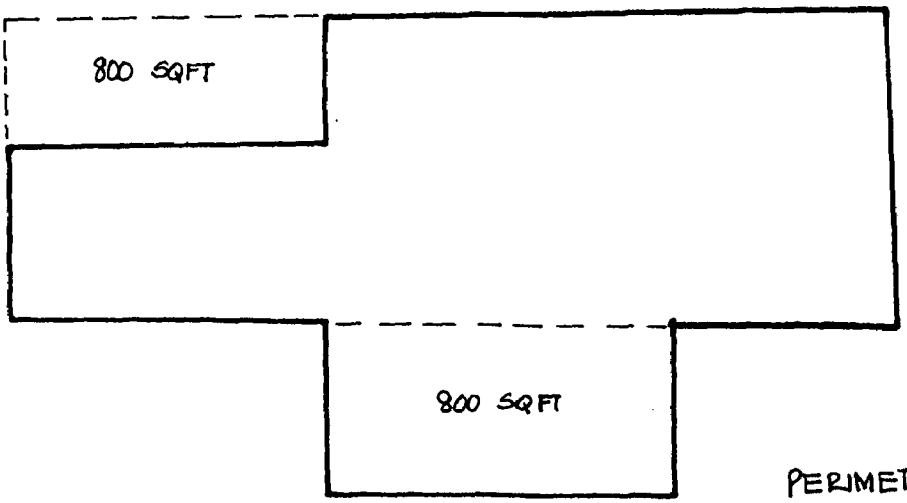




CIRCULATION SPACE V/S PERIMETER.

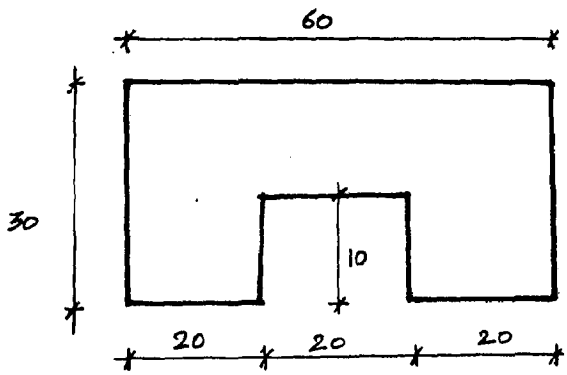


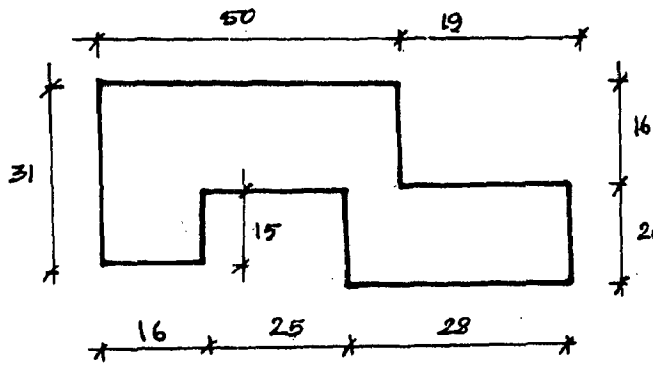


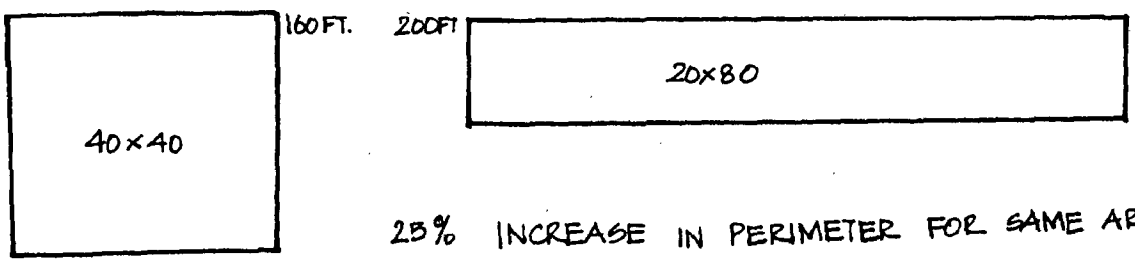


PERIMETER REDUCED BY 12%

200 FT : PERIMETER : 240FT.







25% INCREASE IN PERIMETER FOR SAME AREA

Shape in turn influences the cost per unit of accommodation, due to its effect on the actual quantity of materials and labour required in construction, and its effect on the builders site organisation.

Effect of Shape on Perimeter Costs - The Cost of Enclosing Space

Perimeter cladding and load bearing external walls are high cost items, so the more than perimeter can be reduced without reducing floor area, the more economical a scheme is likely to be.

Cost items involved in perimter are :

(1) Weatherproof external wall construction with facings, finishings, windows and external doors.

(2) Foundations and dampcourse to the external wall or toe to concrete raft including form work.

(3) Parapet or gutter, eaves, fascia etc.

(4) Perimeter columns in a framed structure.

(5) The heat loss through external walls and windows affecting the size of the heating installation.

Effect of Shape on Services and Siteworks

Services and site works tend to become more costly as shape changes from simple to complex. As perimeter increases, service pipe runs become longer, drainage systems

more extended, surrounding paths and siteworks more extensive. The cost of these items may be expected to increase roughly in proportion to the increase in perimeter.

Effect of Shape on Site Construction Cost

Simple shapes are economical to build, especially when combined with simple forms of construction and repetition. Construction time can be saved by taking care in planning to avoid complications of shape and small plan breaks. These tends to slow up work on site and prevent the most efficient use of mechanisation and prefabrication.

Consideration must be given to the effect of shape on the cost of hoisting and positioning materials and other components. On a job which is large enough to merit the use of a crane, greatest economy is obtained if all parts of the building can be reached by it. This is particularly important for the hoisting and rapid positioning of large precast memebrs such as structural beams, precast floor units and cladding panels.

Overall Effect of Shape on Building Cost

A rough guide to the total effect of shape on the over all cost of a building would be :

Complex Shape : between 5 to 10 percent more than simple shape, depending on the proportion which perimeter cost bears to total cost.

(B) Size

Generally, cost does not rise proportionately with increase in plan size. The greater the plan size of a building, the less the square feet cost tends to be :

(a) Effect of Size on Perimeter Costs

The cost of perimeter cladding per F.S. of floor area, varies in inverse proportion to the square root of the floor area.

(b) Effect of Size on Other Limeal Items

Besides perimeter, there are other items, such as partitions, wall, plastering and decoration, skirtings, etc. The cost of which also vary with lineal dimensions, i.e., approx. in proportion to the square root of the floor area, when changes in the size of building are accompanied by proportions changes in the size of rooms. This means that an increase in area of x percent will increase the cost of such items by roughly x/2 percent.

(c) Effect of Size on Cost Per F.S. of Lifts, etc.

The cost of a lift in an office building, of the

bathroom or kitchen in a house or flat, does not vary significantly with changed in size of the building. This is true at least upto the point where any further increase in area would necessitate another lift or a second bathroom.

(C) Circulation Space

The amount of circulation space provided affect the economy of a scheme. The circulation ratio is an important economic factor in design and this is perhaps most obvious in the case of buildings erected for letting, e.g., offices and factories, where the rent return is based in useful floor area.

Circulation space and perimeter is an additional perimeter cost must be calculated and set agianst the saving due to reduced floor area.

Circulation Space and Structural Form

In producing a plan which is economical in circulation space and general planning arrangement, care must be taken to ensure that it also lends itself to an economical structure form.

(D) Height

As a general rule, average cost per sq.ft. increases with the number of storeys. The increase is due to :

(1) The effect on structure of the increased load.

(2) The additional hoisting of materials.

(3) The extra time taken by operatives to reach the higher storeys.

The effect of height on the cost per sq.ft. of various elements of a building will now be considered.

Foundations

In good ground, foundation cost varies with the load more or less proportionately, and in the case of framed structures, is not must affected by structural bay size.

Structure

Structure cost per sq.ft. tends to increase rapidly over the first four sotreys, because of the need to strengthen load bearing walls in the lower part of the building or to introduce some part of framed construction.

Lifts

Average cost per sq.ft. rises sharply when the height is reached at which lifts are introduced. Thereafter, as further storeys are added, the cost per sq.ft. attributable to each lift reduce gradually, owing to the increasing floor area served and the consequent spreading of the lift cost over a greater area.

Plumbing

Plumbing costs tend to increase slightly with height owing to the larger pipes required for main risers and waste stacks, to serve successive storeys.

Finishing and Fittings

Finishing trades are very little affected by the numbers of storeys. Costs are slightly higher on all tall buildings, because of the extra hoisting and time spent climbing to the upper floors.

Roof

The area of the roof is not affected by the number of storeys. Consequently, roof cost per sq.ft. of floor area reduces rapidly for the first few storeys, and then continues to reduce at a much diminished rates.

Site Cost and Density Requirements

High buildings are more usually economical in towns than in the country, owing to the difference in site costs. The extra cost of a high building may be justified on an expenditure town site, where site costs must be spread over a large floor area in order to achieve reasonable economy.

Storey Height

Variations in storey height do not affect the cost of

the horizontal components of a building, e.g., floors and roofs, but have a more or less direct bearing on the cost of vertical components, e.g. stanchions, walls and partitions.

The vertical components of buildings of two storeys or more account for roughly one quarter to one third of total cost.

(E) Structural Form

Cost is often considerably influenced by the form of structure adopted.

Multistorey Reinforced Concrete Structures

When the superimposed loading is not great, the dead weight of construction accounts for a substantial portion of the total load to be carried and reduction of dead load weight produces significant economies.

Slab Thickness (In-situ)

Dead weight is largely governed by slab thickness. Slab thickness can not be reduced beyond limits (related to span) which guard against excessive deformation. Two way spanning helps to reduce slab thickness.

Slab Types

Solid slabs are cheaper to construct than hollow slabs, but have the disadvantage of being heavier. Upto

four storeys, frames with solid slabs are cheaper. Over four storeys, however, hollow slabs produces an overall cost saving due to the saving in beam and column costs resulting from less weight.

Plate construction, i.e., columns and slabs without beams, can be used economically on buildings of certain types, for example, flats and other blocks.

High Grade Materials

Overall cost of frame and floors can be reduced by the use of high grade concrete and reinforcement instead of normal grade, the saving being greatest in the case of heavily loaded structures.

Formwork

Form work costs represent an appreciable portion of total frame cost. The size of beams and columns should, therefore, be standardisation as far as possible throughout a structure, to obtain maximum economy from the resuse of form work. Standardization of sizes can be obtained by varying the steel content.

Pre-Cast Frame

Site construction time may be saved by pre-casting the frames. Usually, however, there is little difference in

cost between precast and in-situ frames when all the factors including haulage and handling are taken into account.

Prestressed Work

A reduction in the depth of floor and beam construction can be achieved by using prestressed concrete. This consequently reduced cladding costs.

* Multistorey steel frames,
* Load bearing cross wall construction
* Single storey steel frames with trusses
  - Portal frames
  - Aluminium frames

(F) Others

(a) Prefabrication

Unless demand is heavy, so that mass production methods can be employed, it is difficult to beat conventional building methods on cost by means of prefabrication.

(b) Standardisation

It is always more economical to reduce the number of size and type variation of any one component used in the same building. The saving lies in manufacturing cost.

(c) Design, Productivity and Repetition

Design can contribute substantially to good productivity and this in turn reduces costs.

There are three main ways in which design can help productivity :

1. Simplicity
2. Continuity
3. Repetition

(d) Site Considerations

1. Location of site
2. Site utilisation
3. Contours

   There are various ways of minimising the extra costs likely to arise on a sloping site, and it may even be possible to turn the slope to advantage.

4. Adjoining buildings

   If an existing building is to be demolished and a new building erected in its place, it may be impossible to avoid the expenses of shoring adjoining buildings.

5. Nature of ground

   The load bearing capacity of the ground and the presence of ground water or rock are factors which greatly affect substructure costs.

(e) Maintenance and Running Costs

Item	Percentage of total maintenance cost	Main Causes
Structural and cladding repairs	10	Roofs, Windows and External doors
External redecoration	25	Protection of wood and iron work
Internal repairs and rennovations	25	Redecoration
Services installations and sanitation	40	Ballvalves tanks and cylinders, burst and blocked pipes.

(f) Quality and Durability

It is decided, for the sake of good appearance, luxury conditions and high durability, to employ expensive materials, lavish finishings, and many constructional refinements, the resultant overall cost may be increased by 50% or more compared with the cost of minimum requirements for the type of building concerned.

2.3.2 Basis of Contract

Some variation in cost may be expected according to the basis on which a contract is placed, and this must be taken into account when estimating and when dealing and deciding upon the form of contract.

2.4 ECONOMICS OF MULTISTOREYED BUILDING

The various costs involved in a multisotreyed buildiny and its components are :

2.4.1 Nature of Costs Involved

The nature of costs that are to be incurred by the client can be illustrated as :

* Cost of construction
* Expenses incurred other than construction before a buildiny can be occupied.
* Life cycle costs

Architectural Building System	Insurances Financing Furnishing Leyal Survey	Financiny Taxes Maintenance Operation
Engineering : Builiny System	Boriny A/E Fees Land	
- Structural - Mech/Eltc.		
Shared system		
Construction Cost	Other Direct/ Indirect costs	Life cylce costs

2.4.2 A break up of the buildiny in terms of the constituent systems for cost distribution is yiven below :

Architectural System

- Roofiny

- Exterior walls
- Partitions
- Wall finishes
- Ceiling finishes
- Specialities
- Fixed equipment

* Engineering Systems

- Foundation
- Floor on grade
- Structural system
- Super structure
- HVAC
- Plumbing
- Electrical

* Shared System

- Conveyeing system

2.4.3 A further detailed break up of the building can be envisaged in terms of its elements, i.e. we move from the above stated broad break up to a finer one :

1. Works below lowest floor finishes.
2. Frame
3. Upper floors
4. Roof
5. Staircase
6. External walls
7. Fitting
8. Windows
9. External doors
10. Internal load bearing walls
11. Partition
12. Internal doors

13. Ironmergency
14. Wall finishes
15. Floor finishes
16. Ceiling finishes
17. Sanitary fittings
18. Decorations
19. Waste, soil and overflow pipes
20. Cold/hot water service
21. HAVC
22. Electrical installations
23. Passenger and goods lifts
24. Fire fighting equipment
25. Special installation
26. Drainage
27. External works
28. Preliminaries
29. Contingencies

A further minute break up of these components can be assumed to be in terms of the material input which shall be:

1. General regarding site works
2. Concrete
3. Masonary
4. Metals
5. Woods
6. Thermal/moisture
7. Doors/windows
8. Finishes
9. Specialities and equipment
10. Special construction
11. Conveying system
12. Mechanical system
13. Electrical system

CHAPTER 3

CHAPTER 3 - CASE STUDIES & DATA COLLECTION

For the puspose of analysis a couple of Multistoreyed buildings have been selected as case studies. The brief and descritpion of these has given below. The case studies are located in Ghaziabad and NOIDA respectively.

3.1 CASE STUDIES

The case studies are as follows :

3.1.1 Kaushambi

15 storeyed group housing at Indrapuam, Ghaziabad.

Architect	:	Jaishwal and Associates
Clients	:	Ghaziabad Development Authority (GDA)
Number of Storey	:	B+15
No. of units on each floor	:	6
Area of each unit	:	1300 sq.ft.
Location	:	Ghaziabad on the N.H. just adjoining Delhi 1/2 hrs drive from Delhi

3.1.2 Anupam

Cooperative Group Housing Society, NOIDA

Architect	:	Adlakha & Associates

Clients	:	Anupam CGHS
Number of Storey	:	8
No. of units on each floor	:	4
Area of each unit	:	
Location	:	NOIDA Sector 6 This drive from C.P.

3.2 Each Architect of the above mentioned case studies was presented with a budget, i.e., the cost limit by the client for the project and had to take certain design decisions to abide by it.

The number of units to be placed on each floor and the height of the building was a combination of the prevailing byelaws, the overall layout, the number of units demanded by the client be it the development authority, a CGHS or a developer. Other criteria affecting the design decisions were the structural form adopted, the individual architect design flair and above and all the existing site and soil conditions.

3.3 STUDY OF DATA COLLECTED ON THE CASE STUDIES

The basic data collected on the case studies which forms the basis for the analysis has been attached as an appendix to the dissertation. The data is broadly under the following category :

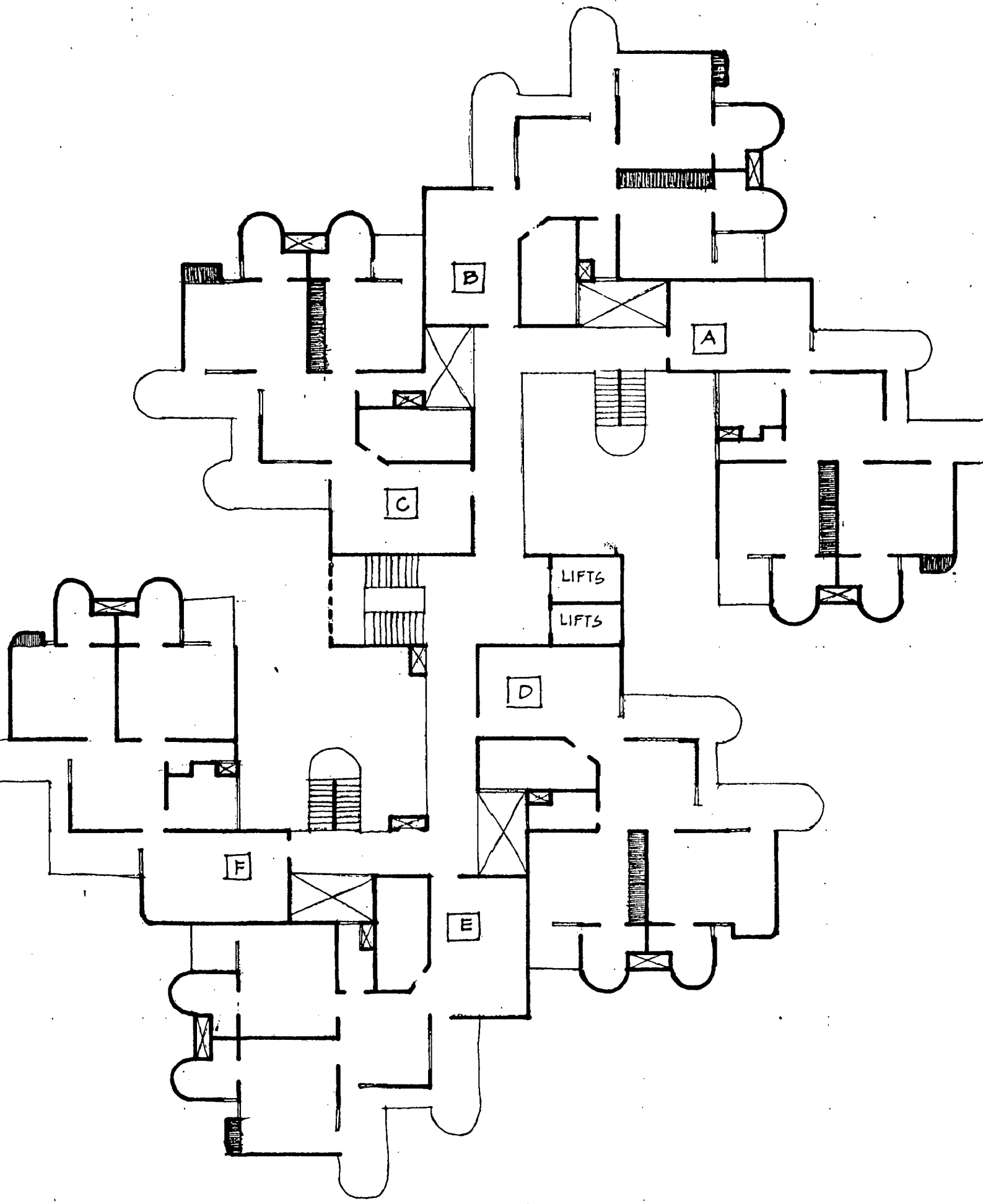


Fig. 4 TYPICAL FLOOR PLAN - KAUSHAMBI

3.3.1 Detailed Working Drawings

* Architectural
* Structural
* Electrical
* Sanitary

for the understading and comprehension of the building design.

3.3.2 Bills of Quantities of the Structure

The bills of quantities have been appended to the dissertation.

3.3.3 Case Studies

 # Kaushambi

Ghaziabad being the part of National Capital Region. It was believed that it would be possible for Ghaziabad Development Authority to develop high rise apartments. These apartments which will cater to the needs not only of Ghaziabad but also to urban area of Delhi. It was desired that the vertical growth in future projects of Ghaziabad Development Authroity should became a hallmark of all design and large areas should be left for conservation of flora and fona and biosphere of the area.

Design concept

A design of two bedroom units which as per needs could

also be converted into 3 bedroom units and one bedroom unit. These 15 storeyed structures consists of 6 flats and each floor serviced by its one side loaded corridor. These blocks have two high speed lifts and one main and two fire escape staircases. The entire configration of the flats in each floors of the building has kept to provide maximum ventilation and orientation quantity to the building as well as provide the advantage in stability of building. Computer analysis of the structure has shown that this fifteen storyed building has a deflection of 1" (one inch) only. It is on account of the form of building and the system followed. The flats consists of :

1.	Drawing Room	12'4" x 18'10.5"
2.	Dining Room	12'4" x 13'10.5"
3.	Bed Room (2 Nos.)	12'4" x 15'7.5"
4.	Kitchens	12'4" x 7'7.9"
5.	Balcony	6'6.5" WD
6.	Toilets	5'0" x 8'0"

 # Brief Specifications for Buildings

1. Foundation

R.C.C. Raft slabs and beams with lean concrete below.

2. Structure

R.C.C. Framed structure with columns, beams, slabs, lintels, walls in 1:2:4 mix, 1:1.5:3 mix and 1:1:2 mix as per design requirements.

3. Core Area

The block has a central core area with a staircase, lobby, three lifts, connecting passage at each floor.

4. Floor Height

The floor to floor height of building is 10'-0".

5. Walls

9" masonry wall in C.M. 1:6 and 4.5" thick brick walls in C.M. 1:4, as filler walls. Necessary R.C.C. walls for lift pits and for rooms etc. have been provided as per design requirements.

6. Flooring

In main buildings, all the rooms and balconies have 40 mm thick mosic flooring, WC baths have ceramic tiles flooring and 7'0" high ceramic tiles dado. All stairs, lobby and passages area have kota stone flooring and skirtings. 40 mm ordinary C.C. flooring with skirtings, is provided for pump room, electrical rooms and cupboard area.

7. Internal Finishing

All walls are provided with 12 mm/15 mm thick cement plaster 1:6. All exposed R.C.C. ceilings, columns, beams, etc. are rendered smooth with 6 mm thick cement plaster.

Distemper on walls and white wash on ceilings.

8. Doors and Windows

Pressed steel frames for doors and rolled steel sections for windows/ventilators/composite door - windows with M.S. handles and peg stays, 10 mm square bar M.S. grills upto ground floor only, 3 mm thick clear glass for windows. Flush door shutters with commercial ply finish on both faces. Mumty, machine room doors are provided with M.S. sheet shutters. Aluminium hardware fittings for doors.

9. Paintings

All doors/windows, railings, grills, etc. will be painted with 2 coats of synthetic enamel paint over the required priming coats.

10. M.S. Railings Etc.

M.S. Square bar balustrades for staircase railing with M.S. flats on side and top with PVC handrail. All balconies, will have R.C.C. cast in-situ railing with 12 mm square bars in voids/gaps.

11. External Finishing

Washed marble chips are provided on external wall surface.

12. Roofing, O.H. Tank, Machine Room, Mumty

Bitumen painting of terrace roofs, six course water proofing treatment with fibre base felt layers, C.C. gola alround, C.C. khurrahs.

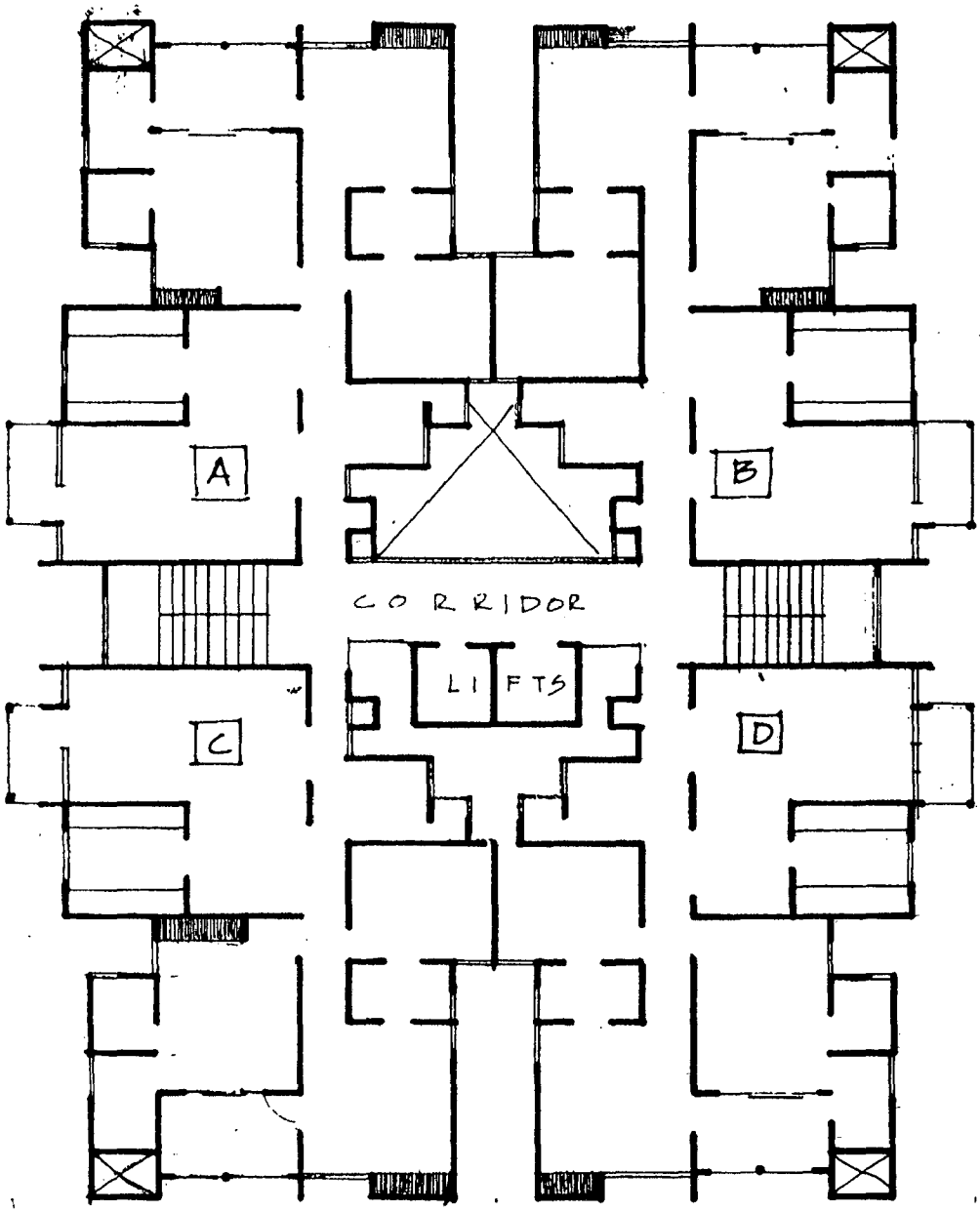


Fig. 5 TYPICAL FLOOR PLAN (ANUPAM TYPE: A

R.C.C. Overhead tanks with C.I. covers for openings. Machine room with R.C.C. slab for lifts is also provided. Roofing treatment to mumties and machine room also is similar to main terrace.

13. Approved Materials

(i) Stone aggregate from quarries at 'Gurkul (Haryana)' for CC/RCC work.

(ii) Coarse sand from 'Badarpur', Delhi.

(iii) Mild/Tor steel of I.S. standards requirements.

(iv) Rolled 'Man' 'Mahabir' or equivalent sections for windows.

(v) Sitapur or equivalent flush door shutter.

(vi) Hardware aluminium fittings for 'ECIE/Adarsh' or equivalent.

(vii) Water proof cement paint of 'Snowcem' equivalent.

(viii) P.V.C. hand rail of 'fixopan' or equivalent.

(ix) 'Cico' water proofing compound.

(x) Samples of all other materials will be got approved from Architects/Engineers.

 # Anupam CGHS

Area of plot	:	130.0x51.87 = 6743.10 sqm
Total number of dwelling units	:	100

Location of plot	:	NE : Park
		NW : Road
		SE : Other's plot
		SW : Road 24.0 m
Types of flats	:	Type A = Plinth area = 160.93
		No.of flats = 50
		Type B = Plinth area = 119.68
		No.of flats = 50
Stilts	:	All flats are on stilts (Type A & B)
No. of blocks	:	4

Main Features of Type 'A' and Type 'B' Flats

Type 'A' 160.93 sqm		Type 'B' 119.69 sqm	
1	Living/Dining	1	Drawing
3	Bed Room	2	Bed Room
1	Kitchen	1	Kitchen
2	Toilets	2	Toilets
1	W.C.	1	Store
1	Store	1	Lobby
2	Covered Verandah	2	Covered Verandah

Each type has been categorised/grouped in separate blocks and have separate lifts. The society intends to bear maintenance and running cost by residents of individual blocks independently. Each flat has minimum three sides elevation.

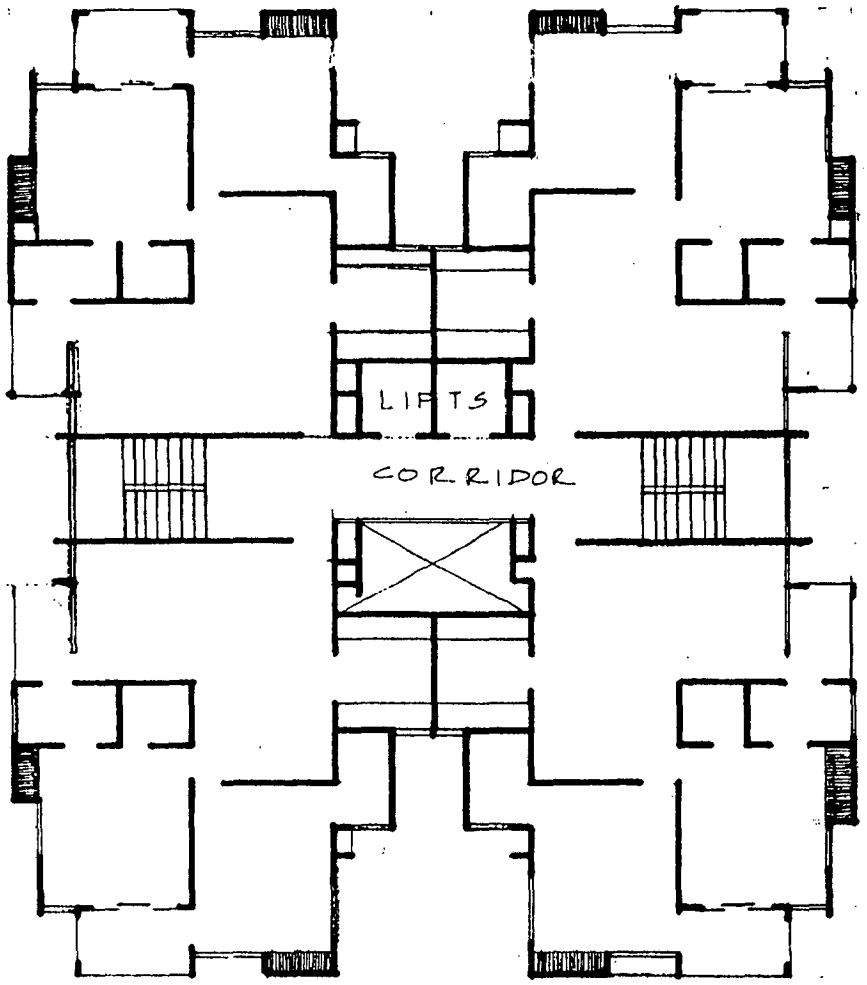


Fig. 6 TYPICAL FLOOR PLAN (ANUPAM TYPE:B)

Stilt has been provided. Stilt in Block (Type B) has been used for electric sub-station.

Type A = 8 storeyed (S+7)

Type B = 8 storeyed (S+7)

Common Facility of the Society

1. Lift - 8 Nos.
2. Fire fighting
3. Garbage chute
4. Generator facility for house and lift
5. Intercom facility at the soceity office
6. Common T.V. antenna.

Brief Specifications

1. Structure

R.C.C. framed structure, common and external wall 9" thick internal portion 4½" wall.

2. Terracing

Lime concrete with brick tiles.

3. Finishing

Internal walls with plaster finishing with dry distemper and external finish mossaic wash with ordinary cement and butchwork on arches.

4. Flooring

Marble floors in Drawing/Dining room, toilets, mossaic floors in bed rooms, verandah, corridors, staricase. Kota Stone flooring in kitchen.

5. Doors and Windows

Champ wood chaukats, flushdoor, glazzed shutter.

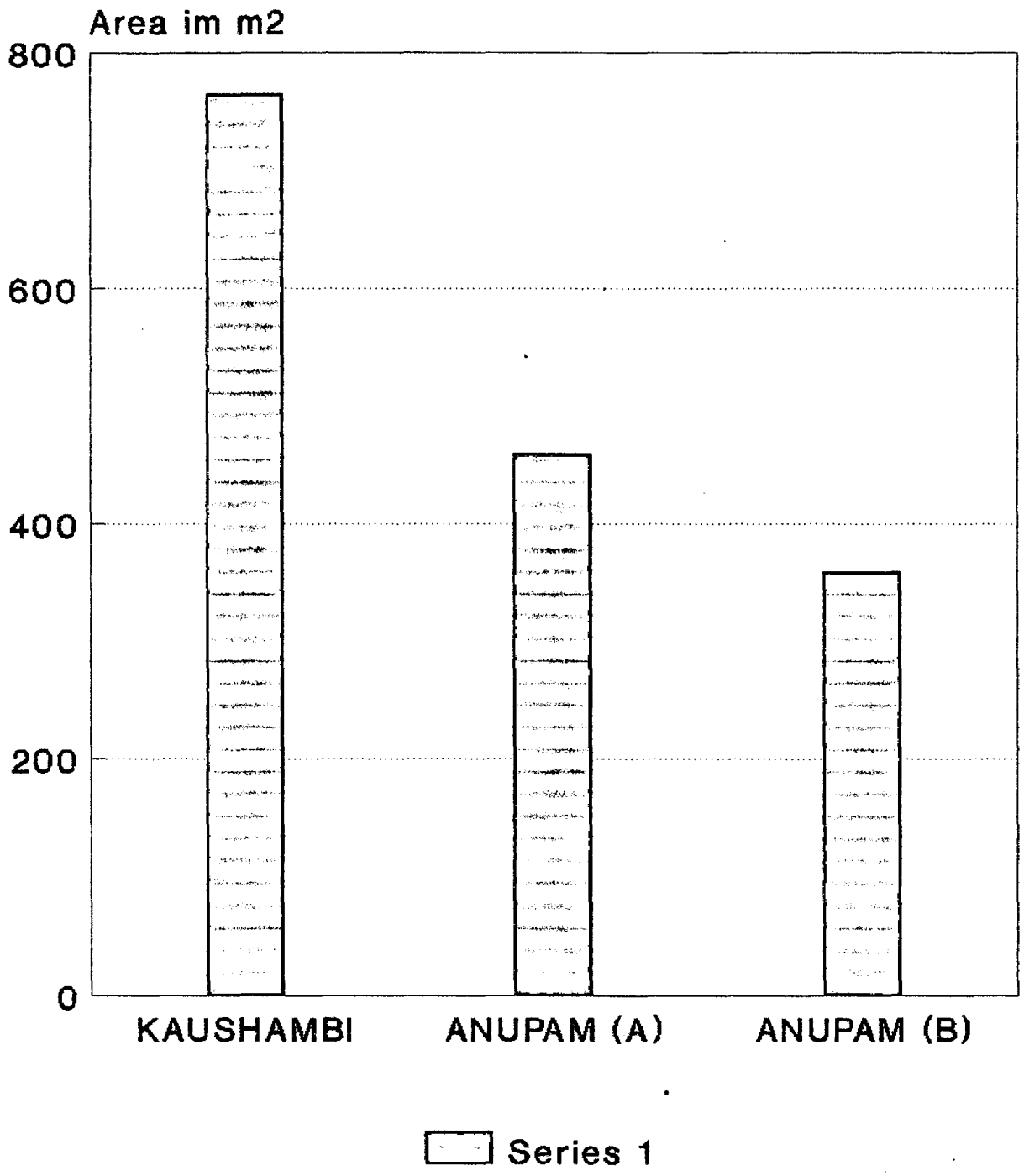
6. Sanitary and Water Supply

G.I. and C.I. pipes for water supply and soil waste water, hot and cold water provision in all toilets and kitchen white china sanitary wares etc.

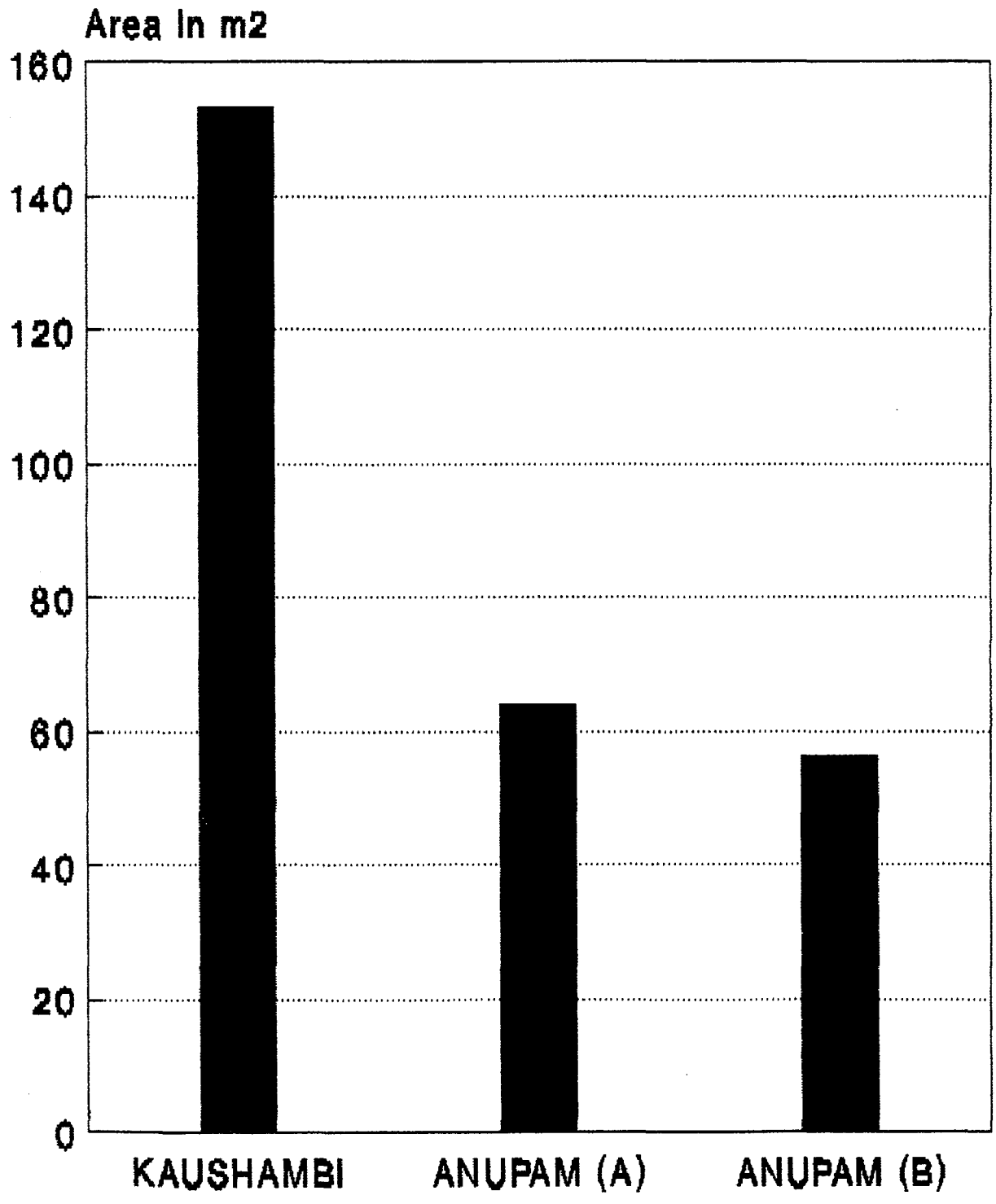
7. Electric work

Concealed G.I. conduit wiring with bakelite sheet and anchor switches.

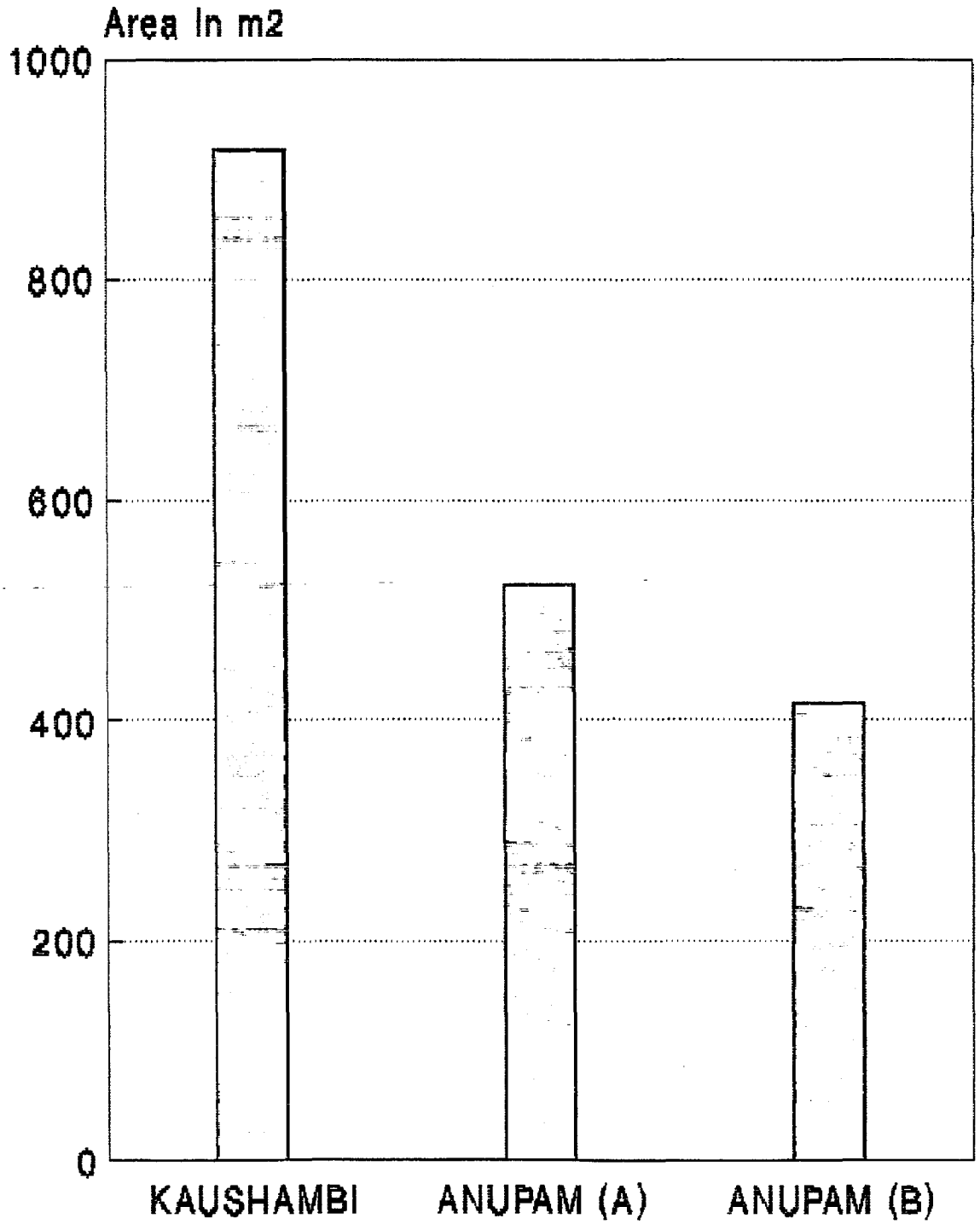
NET AREA ON EACH FLOOR



COMMON AREAS



GROSS AREA ON EACH FLOOR



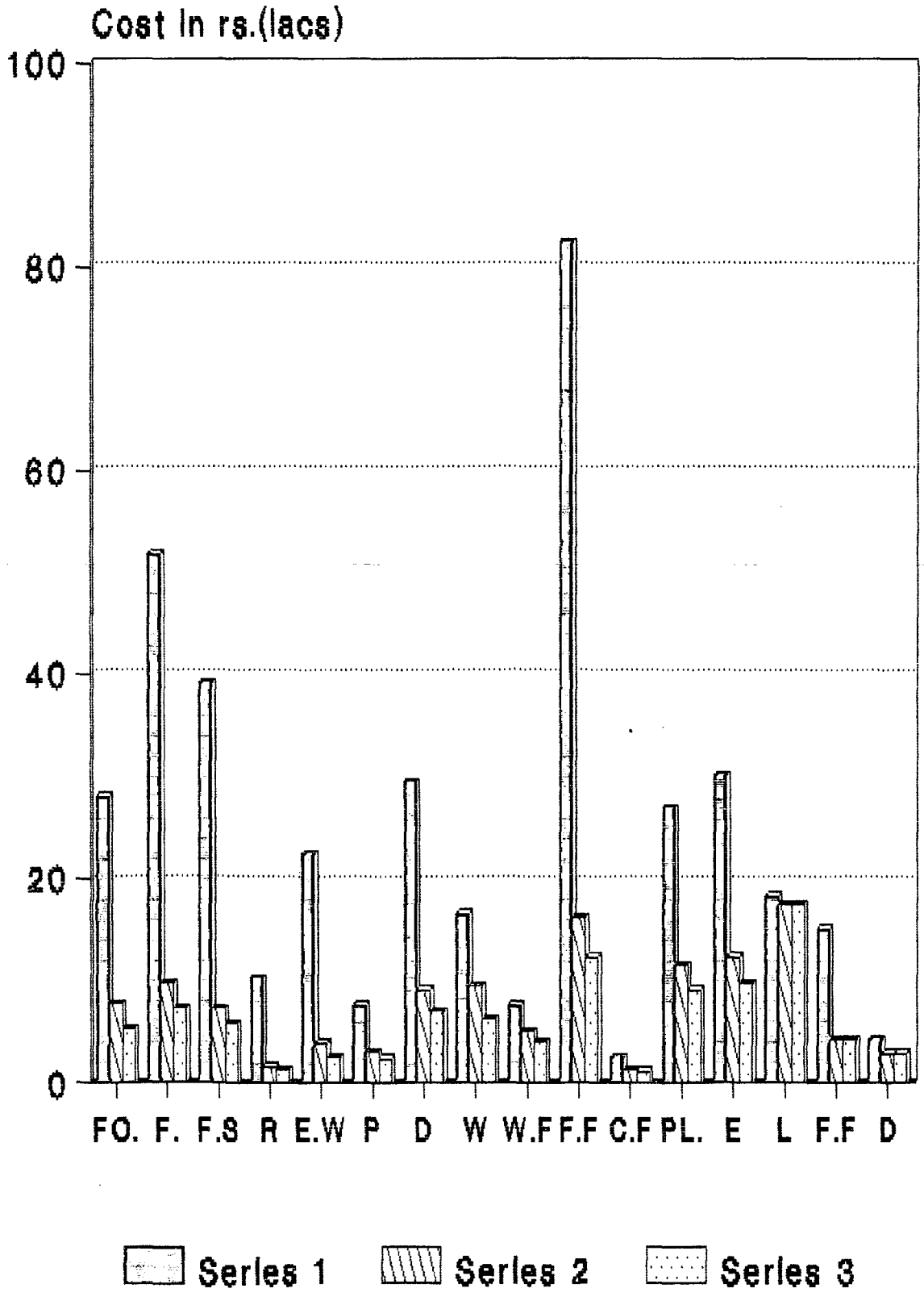
AREAWISE BREAKUP

S.No.	Item	Kaushambi	Anupam Type A	Anupam Type B
1.	Area of each unit (m^2)	127.5	115.0	90.0
2.	Net area on each floor (m^2)	765.0 83.3%)	460.0 (82.8%)	360.0 86.4%)
3.	Common area (m^2)	153.3 (16.7%)	64.0 (12.2%)	56.5 (13.4%)
4.	Gross area in each floor (m^2)	917.5	524.0	416.5
5.	Length of perimeter walls on each floor (m)	332.4 (0.435) m/m^2	198.0 (0.43) m/m^2	140.0 (0.389) m/m^2
6.	Length of Internal walls on each floor (m)	201.2 (0.263) m/m^2 Net area	161.6 (0.35) m/m^2	143.8 (0.399) m/m^2
7.	Total area on all floors (m)	15,589.0	3,668	2,916.0

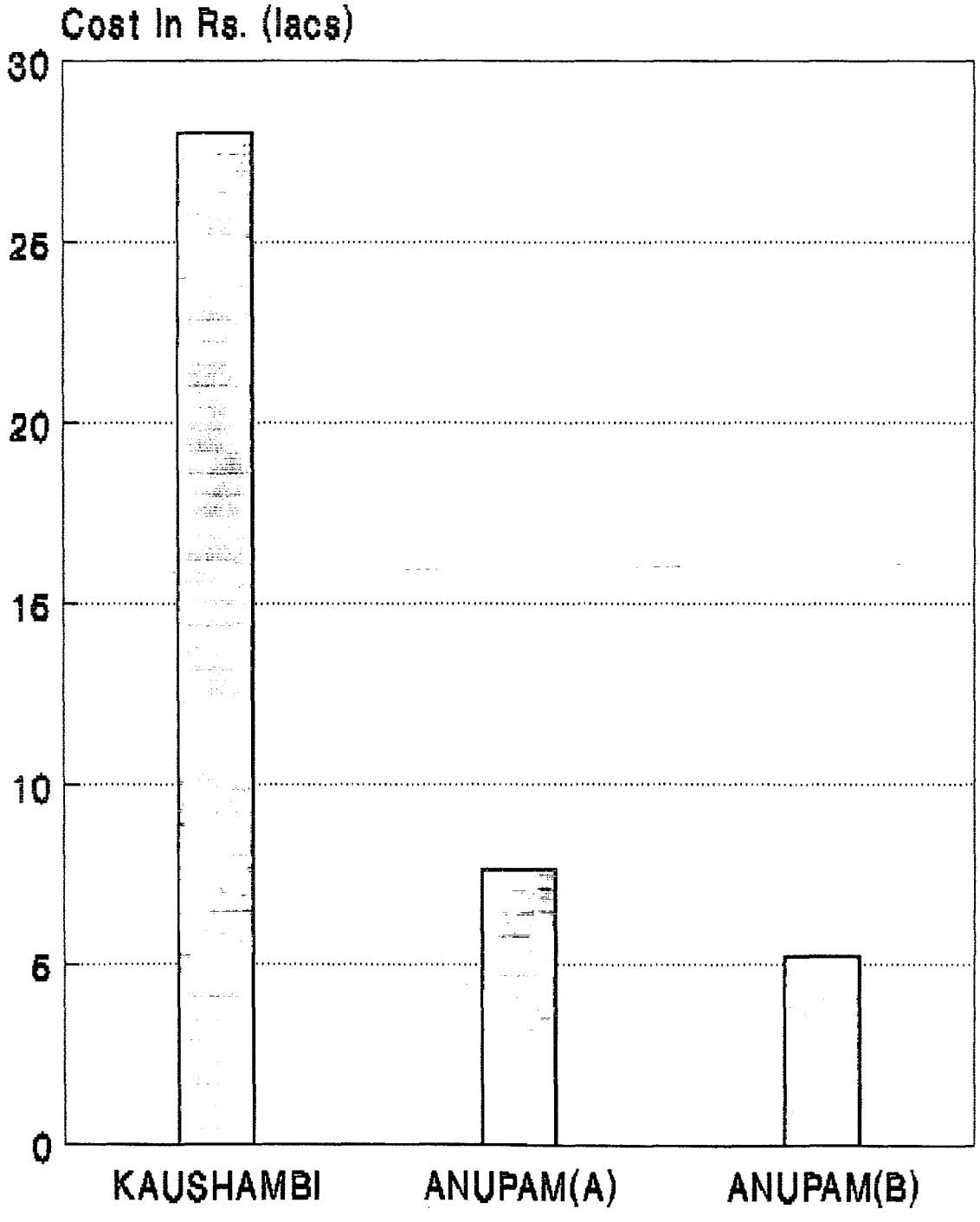
COST BREAK UP OF INDIVIDUAL BUILDING ELEMENTS (IN RS)

Sl. No.	Item	Kaushambi	Anupam Type A	Anupam Type B
1.	Foundation	28,07,055	7,70,580	5,24,725
2.	Frames	51,82,008	9,68,645	7,27,820
	(a) Beams	20,91,075	4,57,070	3,33,970
	(b) Columns	27,30,020	4,16,960	3,02,328
	(c) R.C.C. Walls	3,60,913	94,615	91,530
3.	Floor slabs	39,22,642	7,21,885	5,70,455
4.	Roofing	10,19,225	1,57,625	1,20,250
5.	External Walls	22,44,963	3,82,450	2,48,997
6.	Partitions	7,62,300	3,04,710	2,43,400
7.	Doors	29,47,927	9,13,072	7,04,894
8.	Windows	16,64,664	9,44,516	6,25,421
9.	Wall finish	7,63,077	5,04,213	3,96,965
10.	Floor finish	82,32,772	16,23,400	12,31,230
11.	Ceiling finish	2,52,677	1,28,781	1,08,469
12.	Plumbing	26,93,890	11,44,000	9,10,000
13.	Electrical Installtions	30,24,988	12,41,500	9,75,000
14.	Lifts	18,30,000	17,50,000	17,50,000
15.	Fire fighting	15,05,000	4,25,000	4,25,000
16.	Draiange	4,24,785	2,92,500	2,92,500

COST BREAKUP OF INDIVIDUAL BLDG. S



FOUNDATION


Cost In Rs. (lacs)
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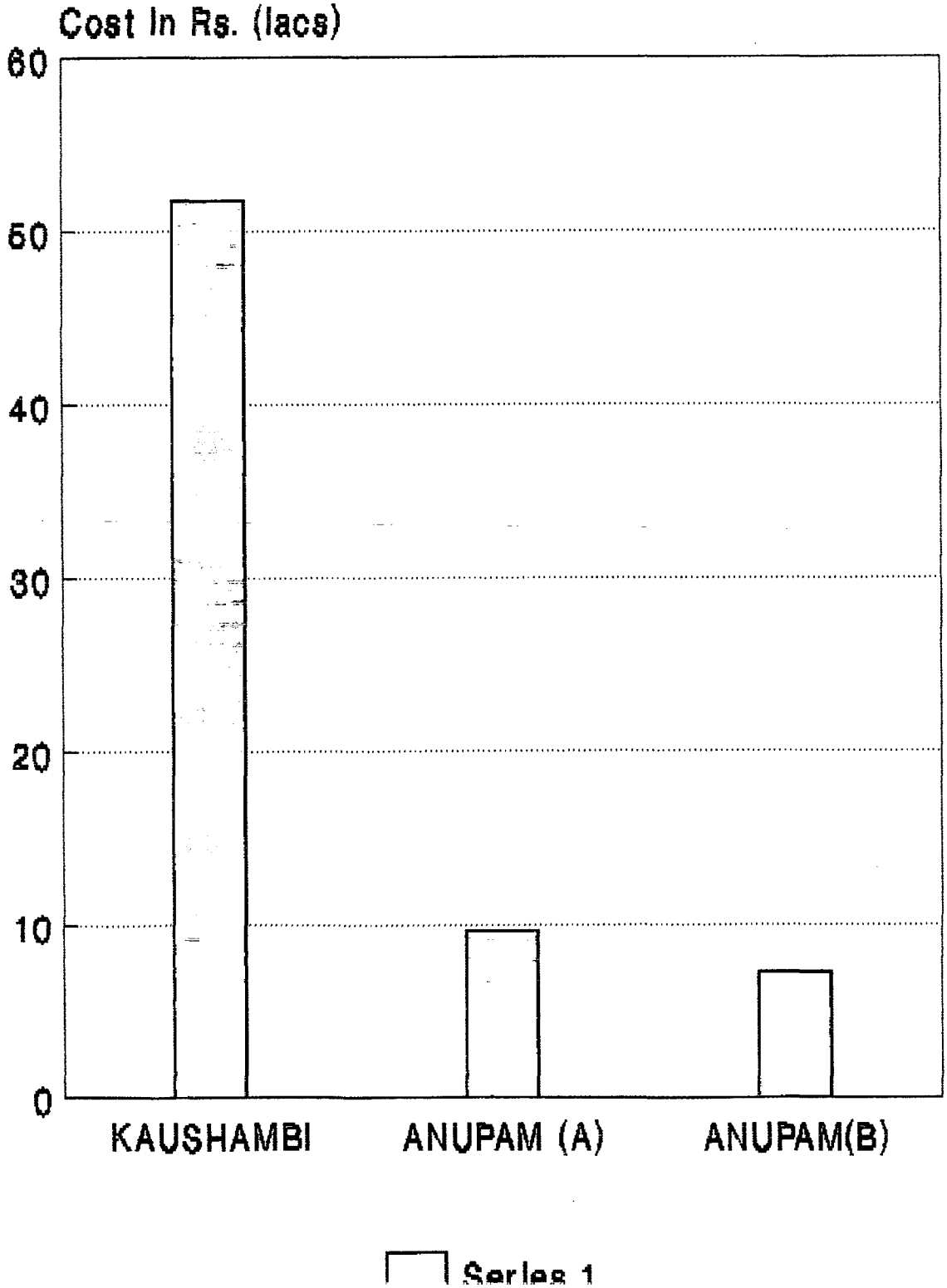
25
20
15
10
5
0
KAUSHAMBI
ANUPAM(A)
ANUPAM(B)
Series 1

FRAMES


Cost In Rs. (lacs)
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30
20
10
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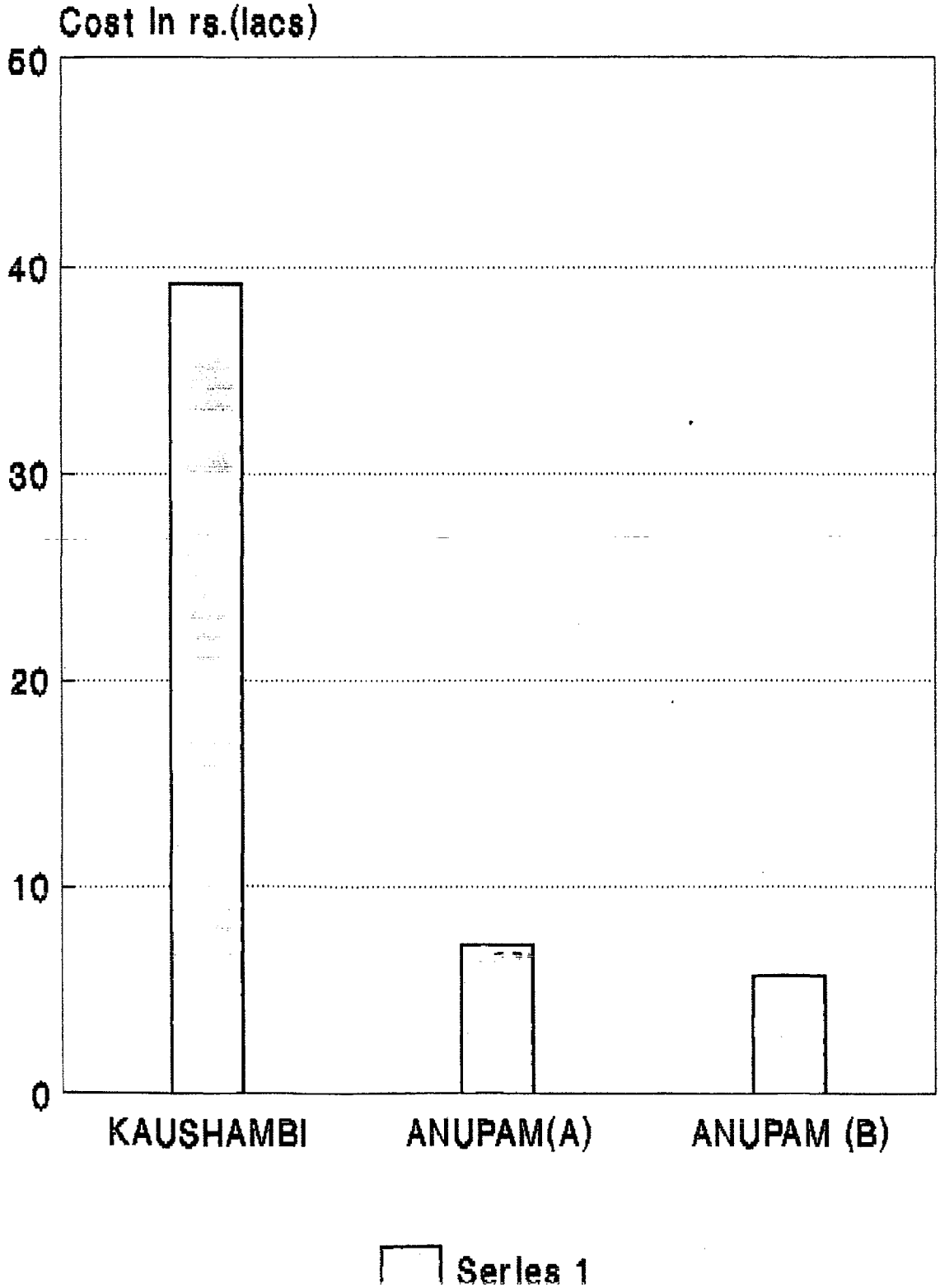
KAUSHAMBI
ANUPAM (A)
ANUPAM(B)
Series 1

FLOOR SLABS


Cost In rs.(lacs)
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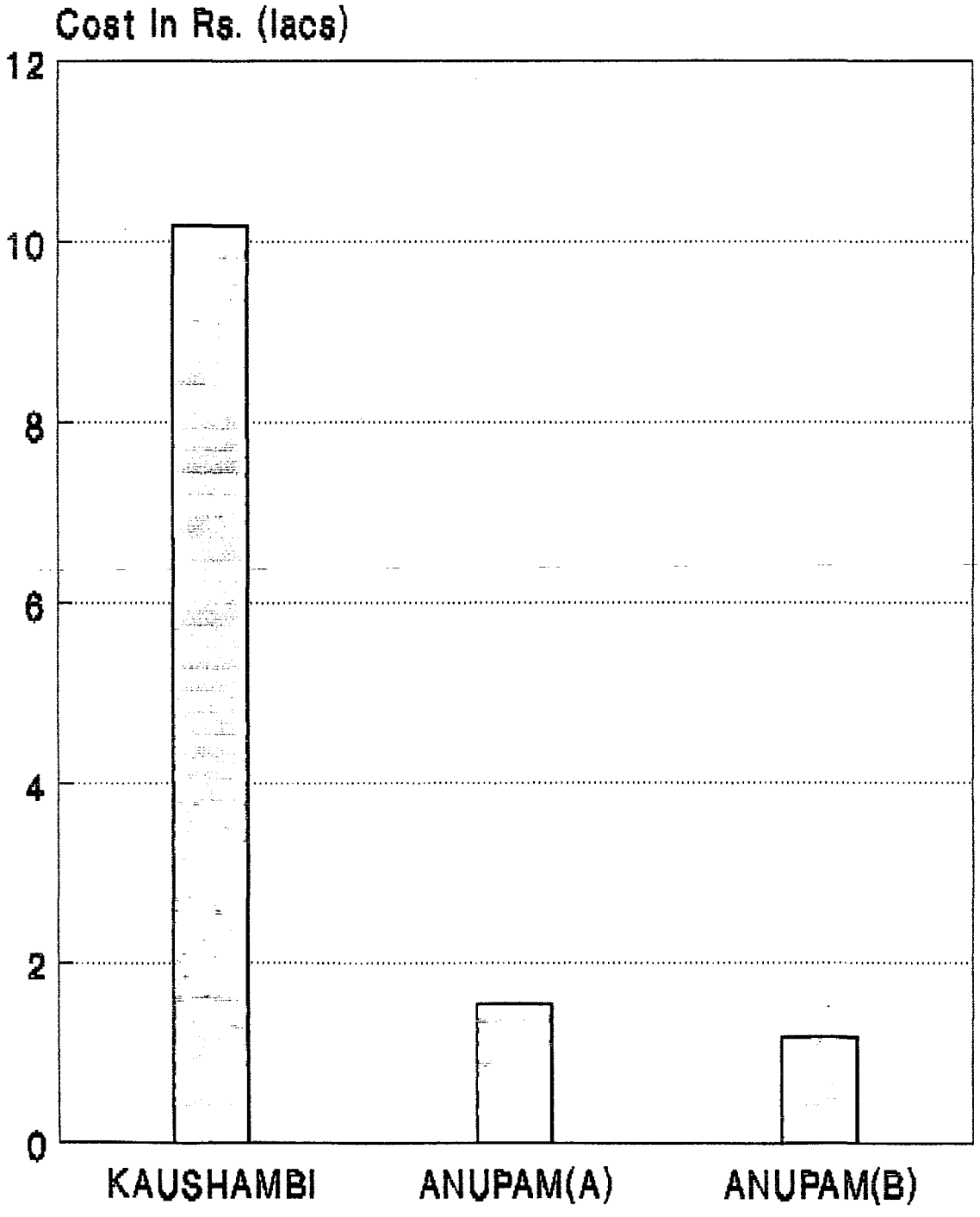
40
30
20
10
0
KAUSHAMBI
ANUPAM(A)
ANUPAM (B)
Series 1

ROOFING


Cost In Rs. (lacs)
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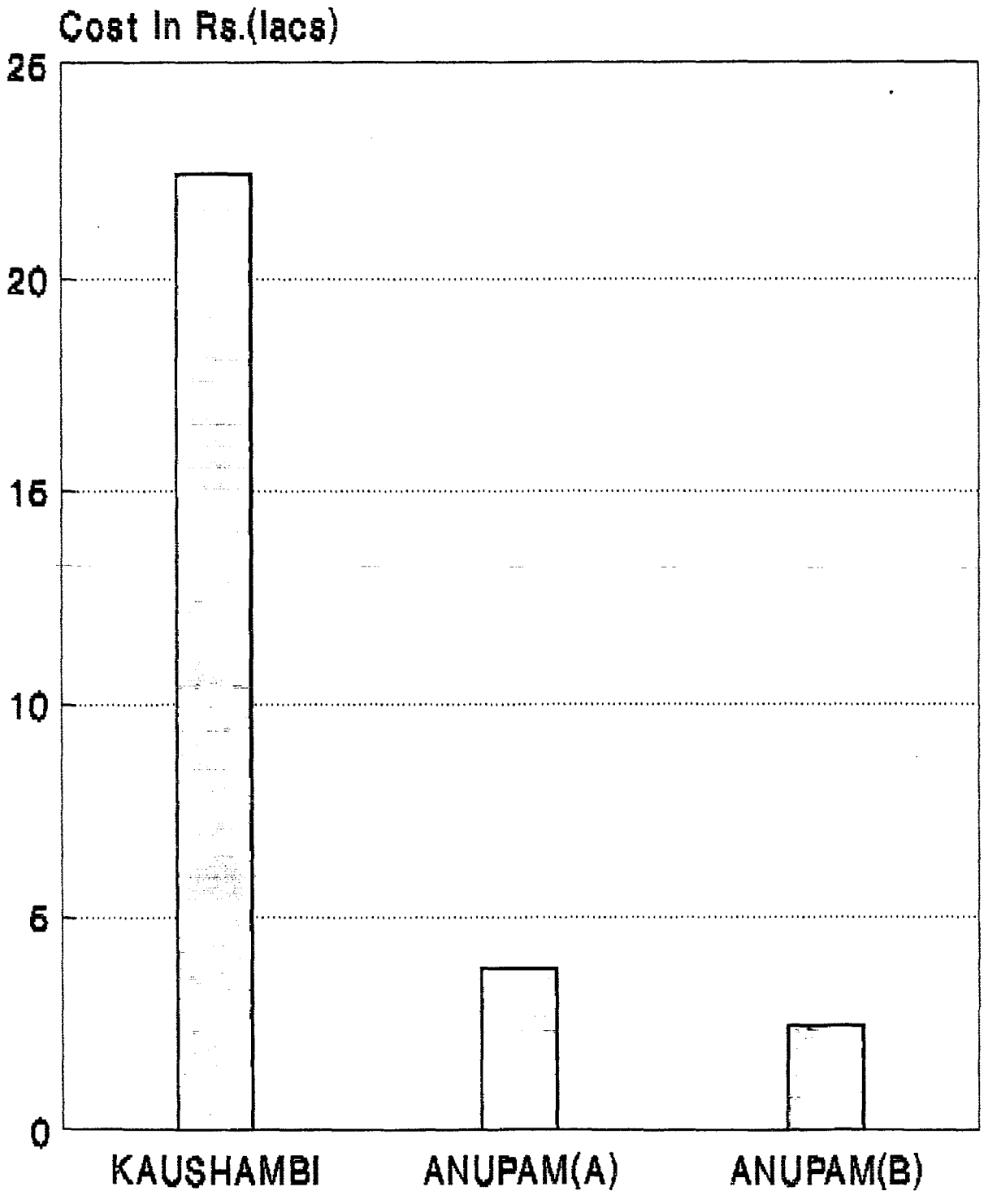
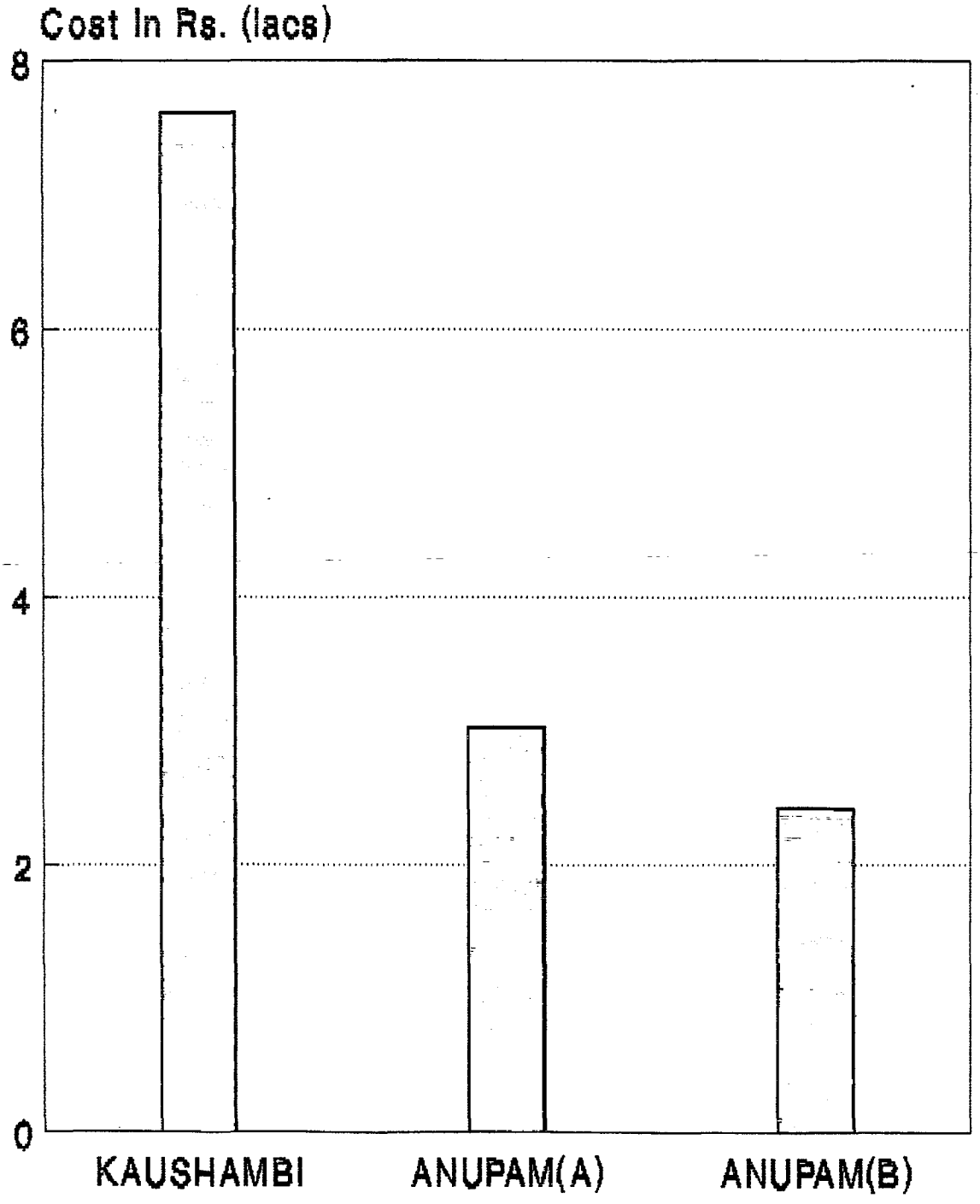
10
8
6
4
2
0
KAUSHAMBI
ANUPAM(A)
ANUPAM(B)
Series 1

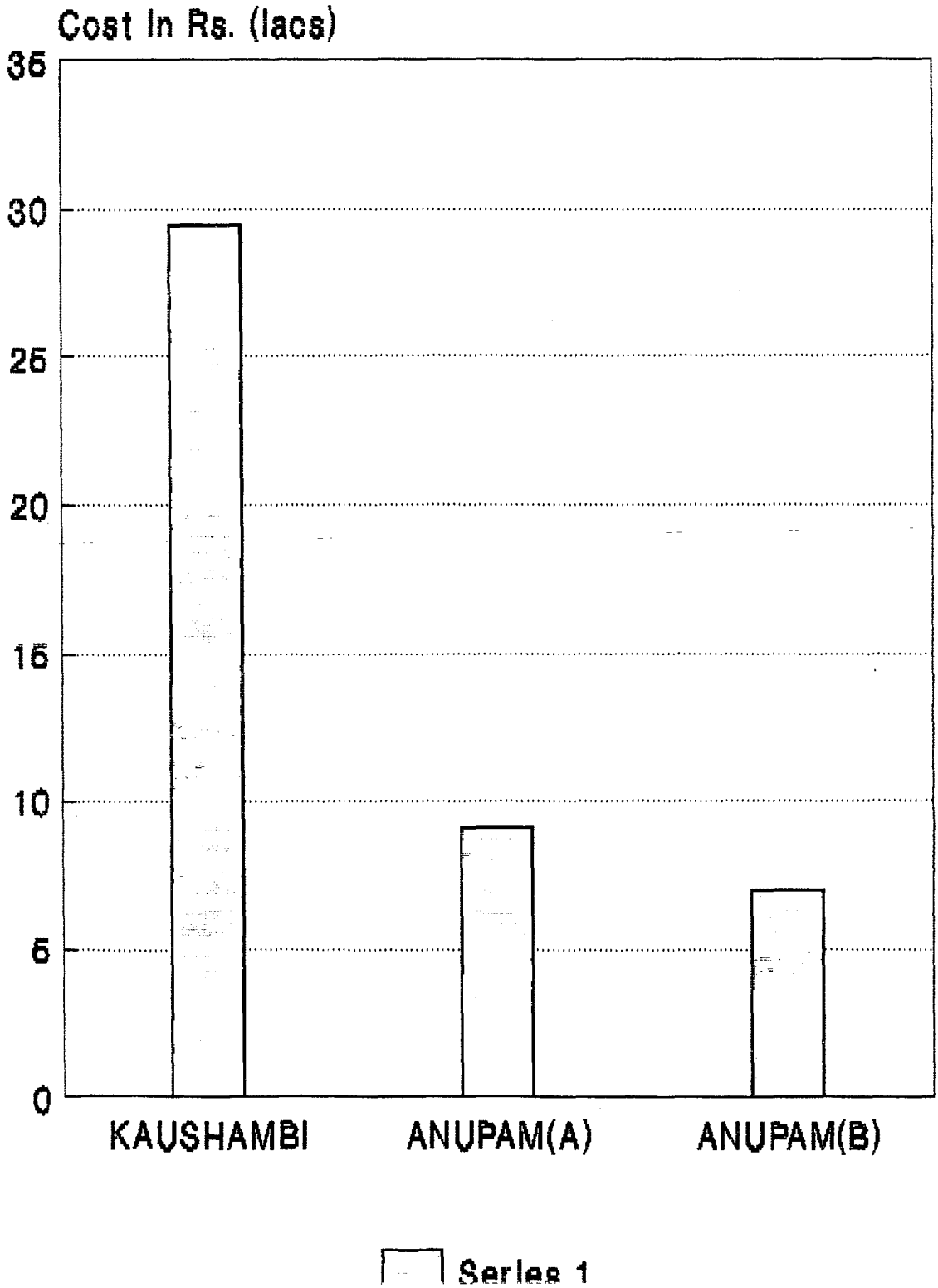
EXTERNAL WALLS



PARTITIONS



DOORS


Cost In Rs. (lacs)
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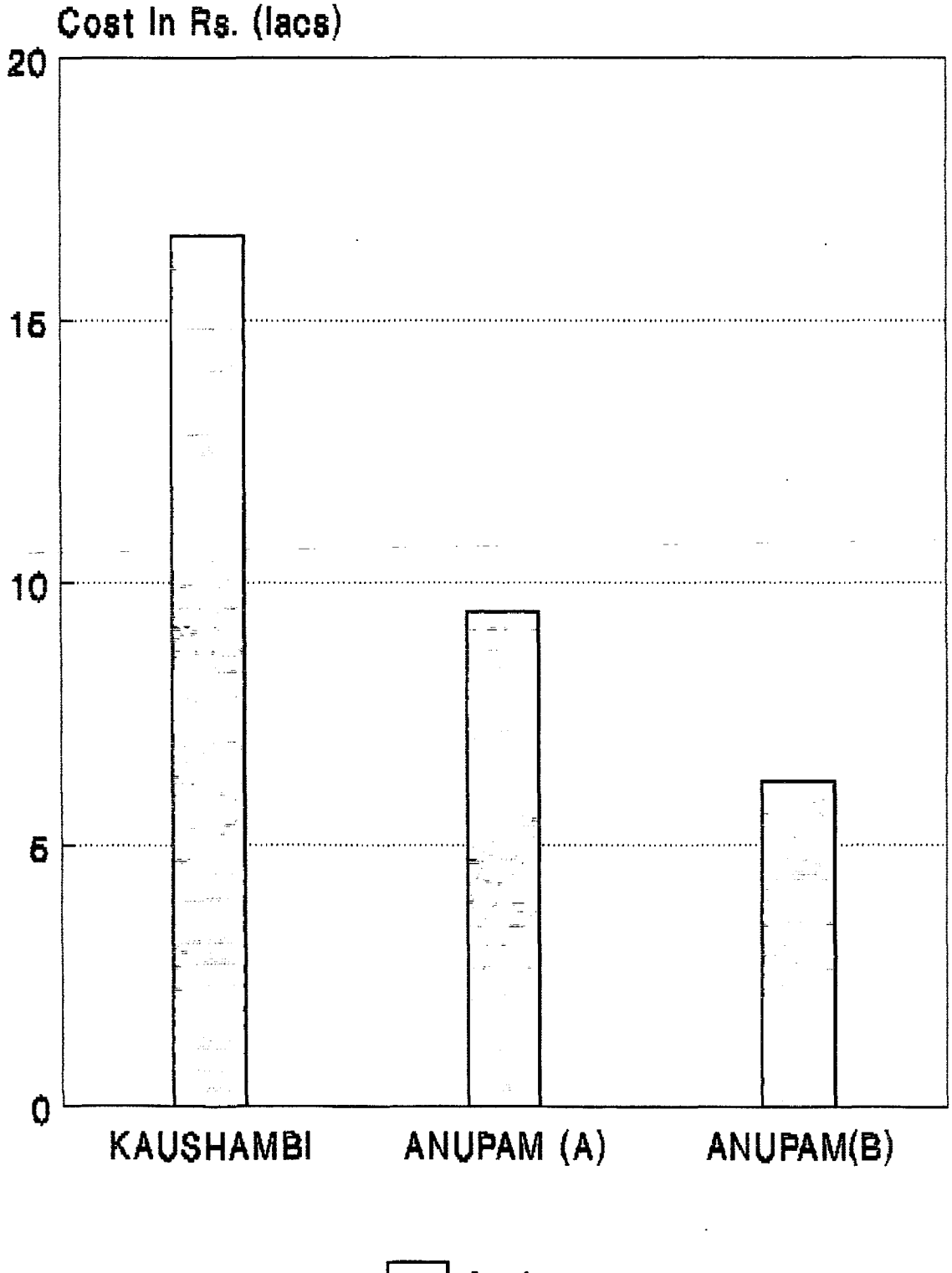
25
20
15
10
5
0
KAUSHAMBI
ANUPAM(A)
ANUPAM(B)
Series 1

WINDOWS


Cost In Rs. (lacs)
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15
10
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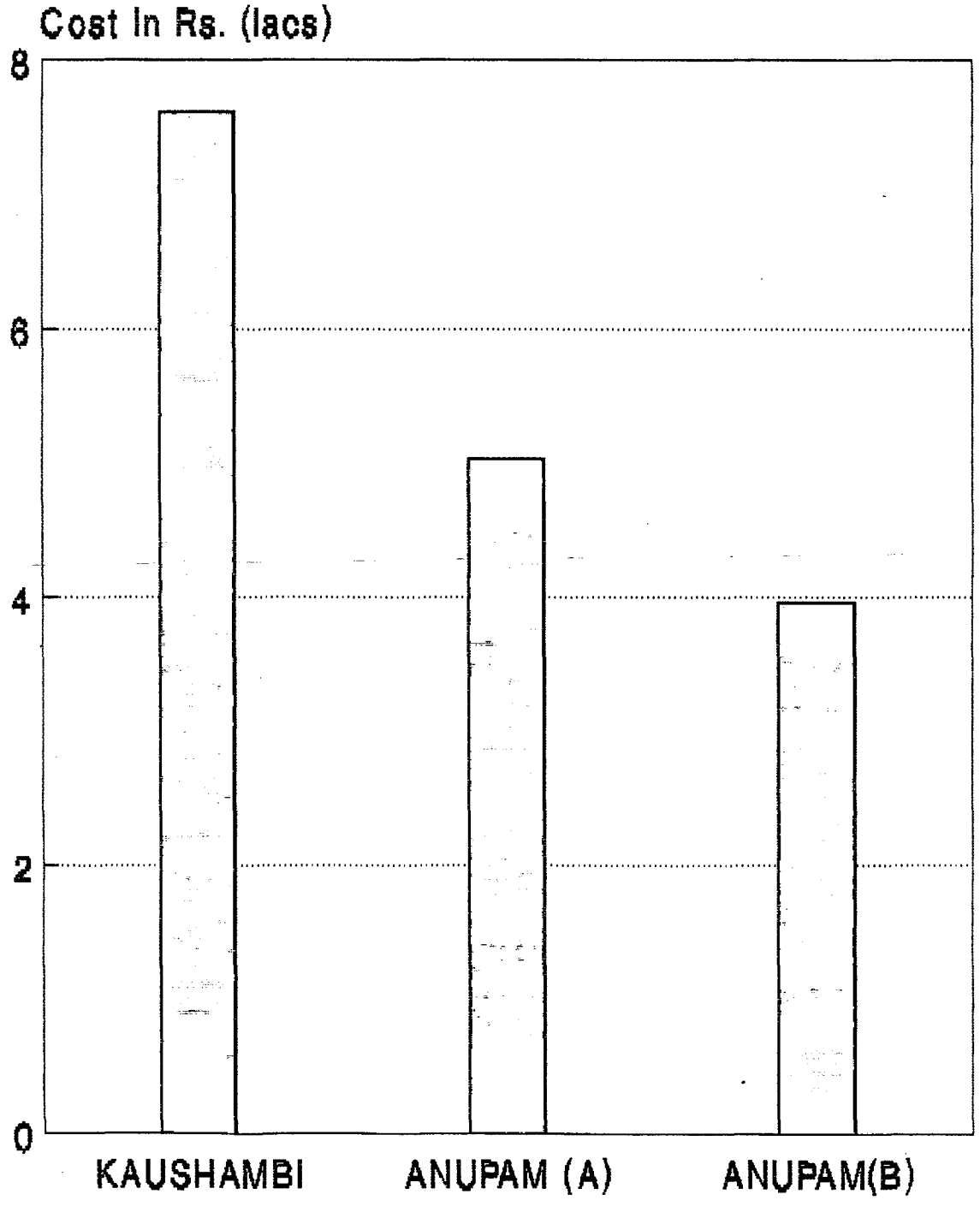
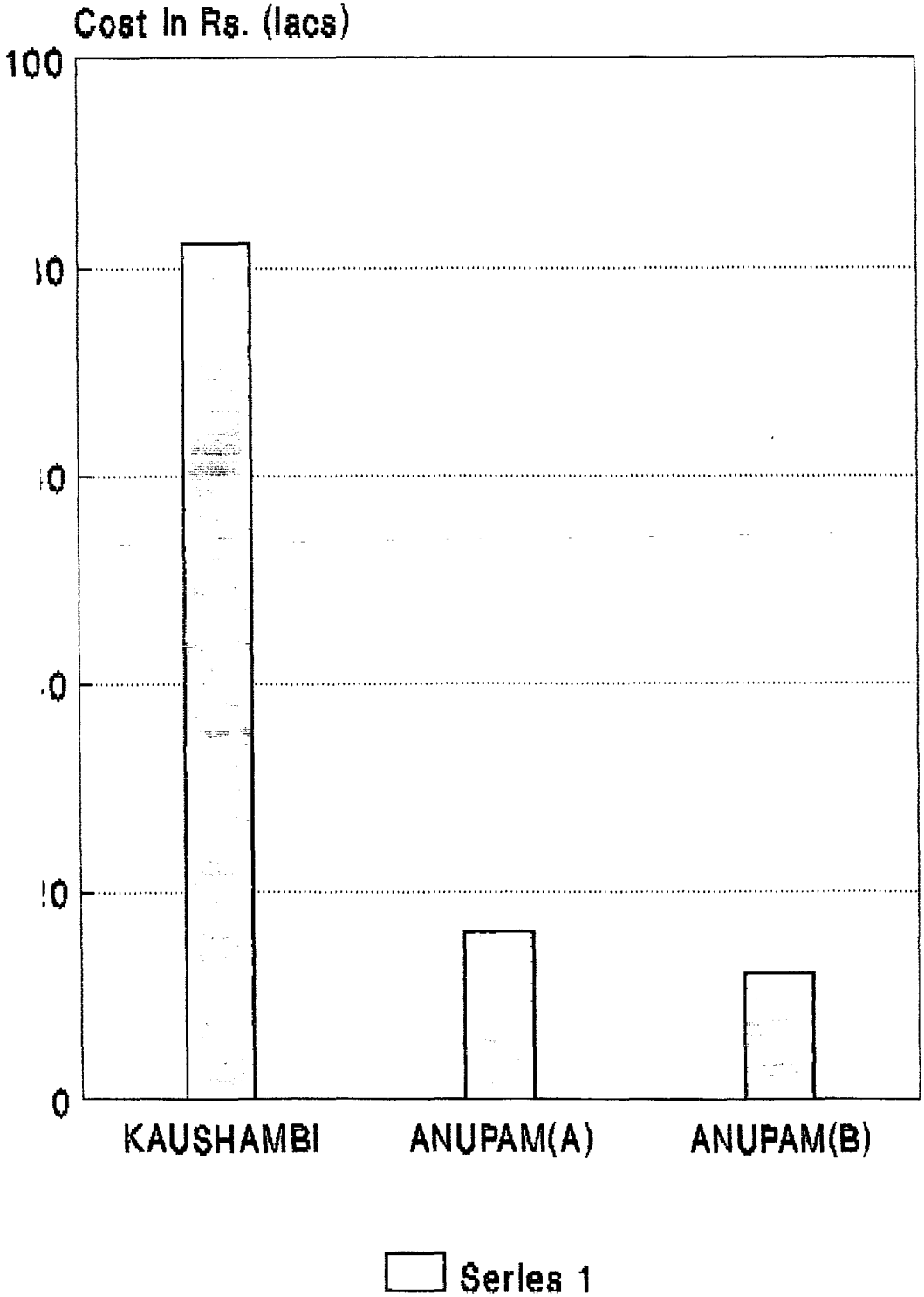
KAUSHAMBI
ANUPAM (A)
ANUPAM(B)
Series 1

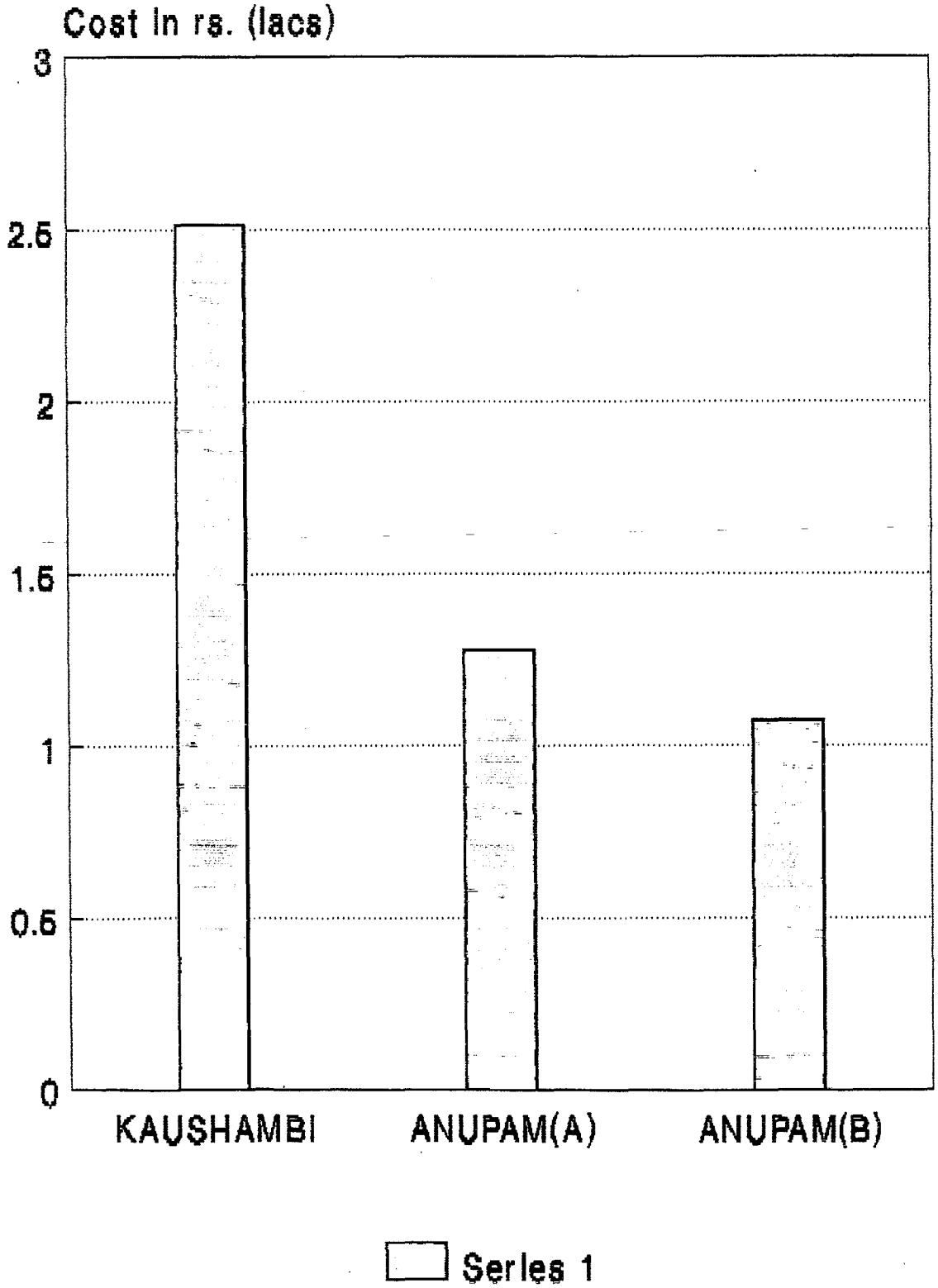
WALL FINISH



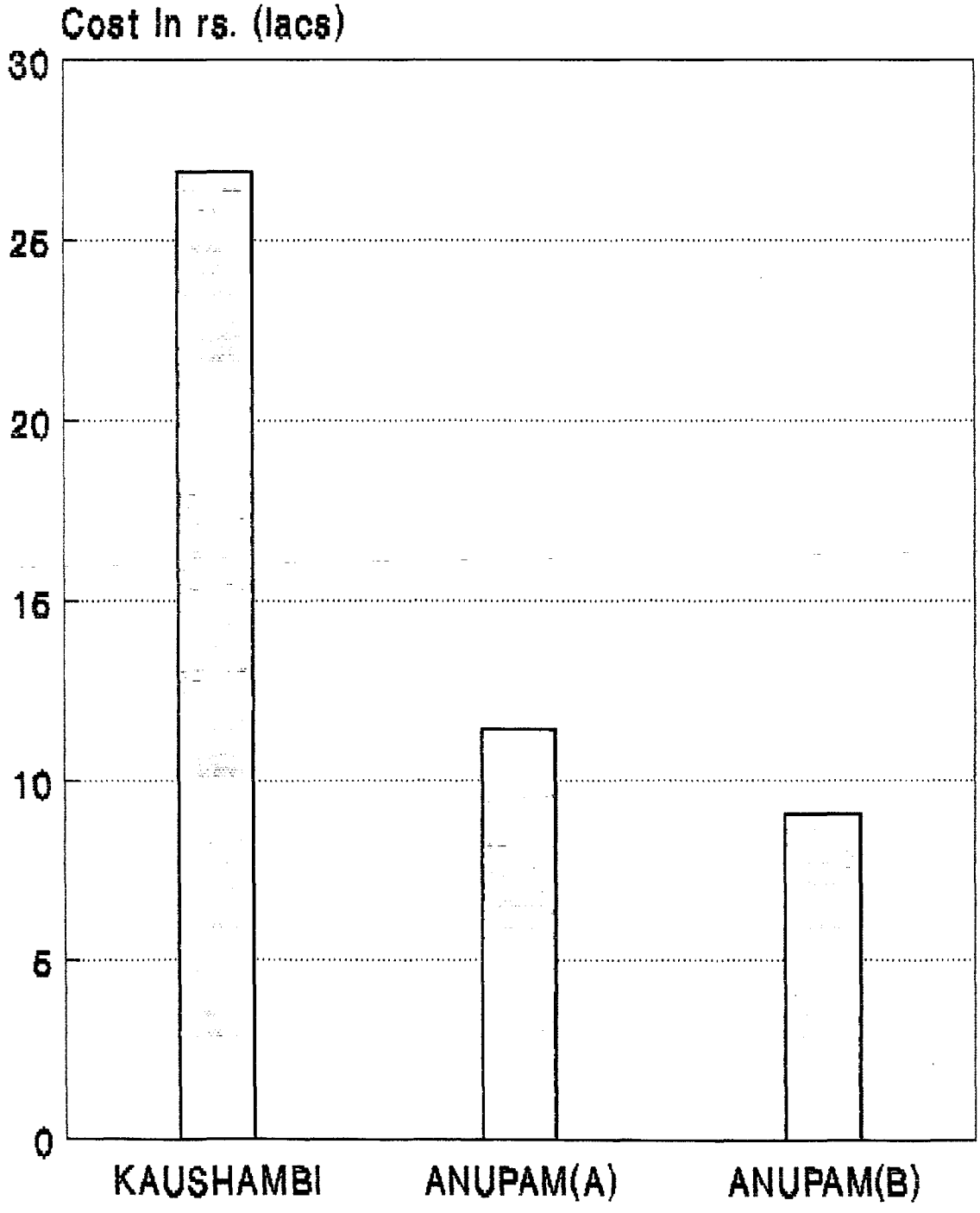
FLOOR FINISH



CEILING FINISHES



PLUMBING


Cost In rs. (lacs)
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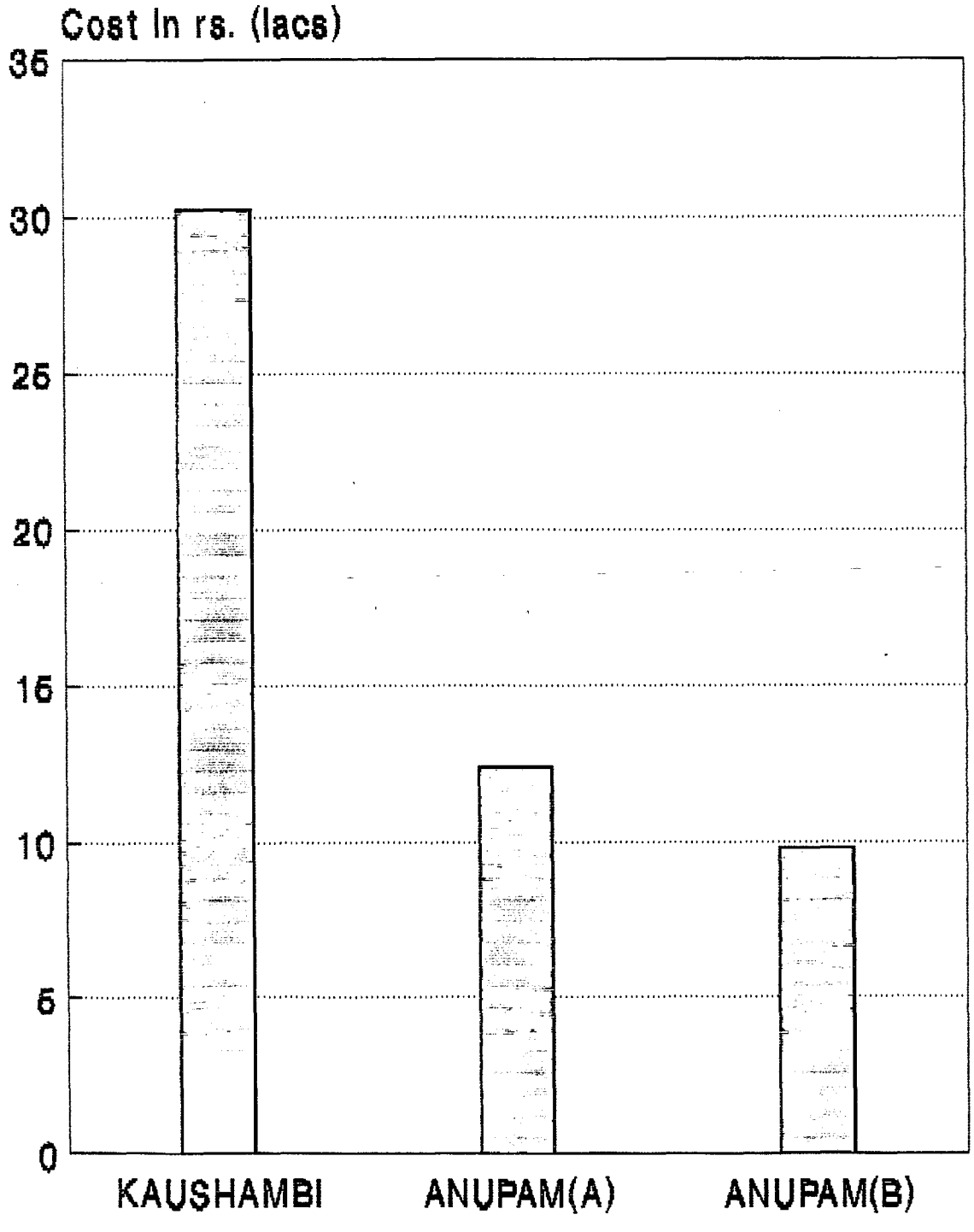
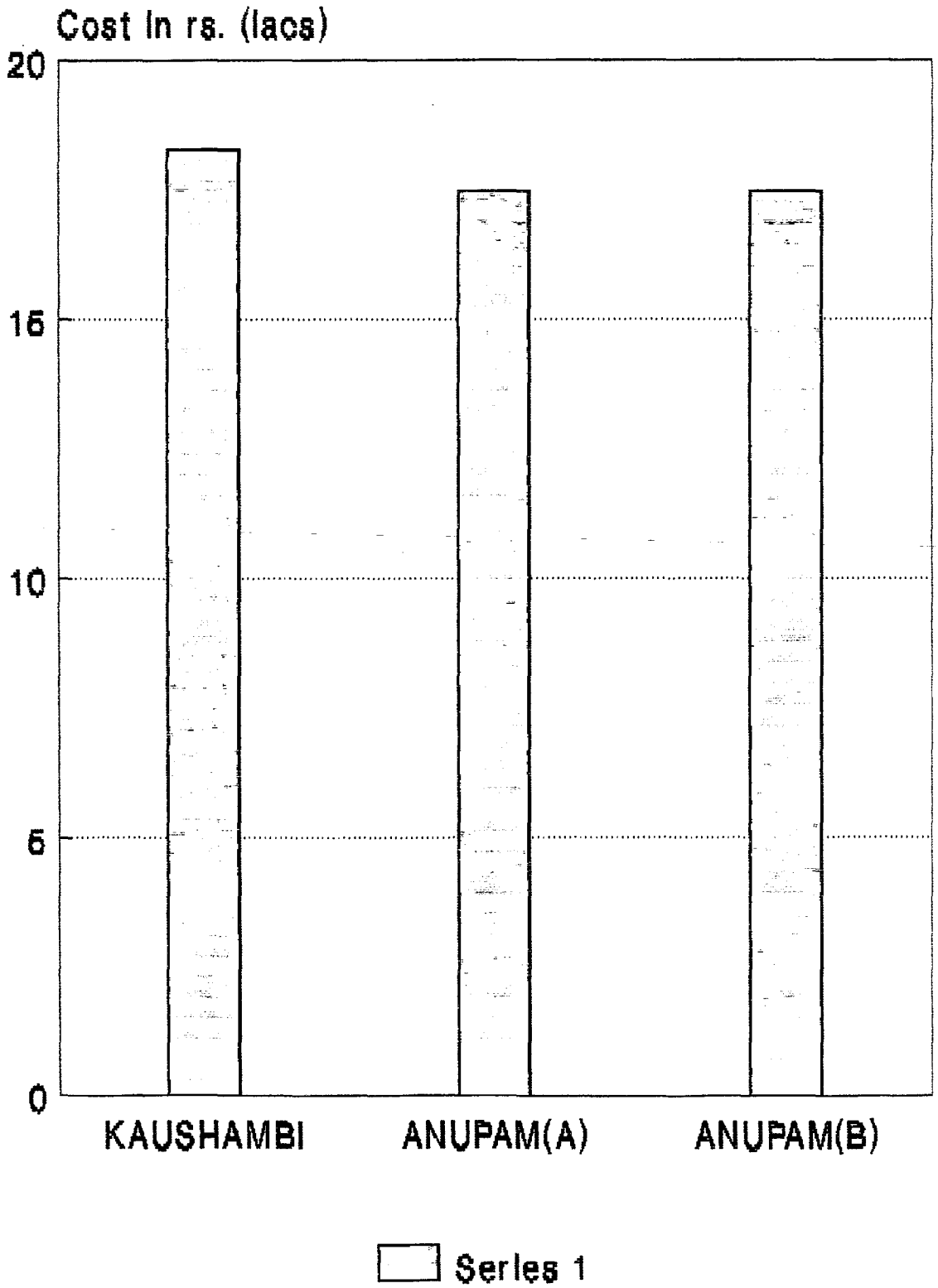
20
15
10
5
0
KAUSHAMBI
ANUPAM(A)
ANUPAM(B)
Series 1

ELECTRICAL INSTALLATION



LIFTS


Cost In rs. (lacs)
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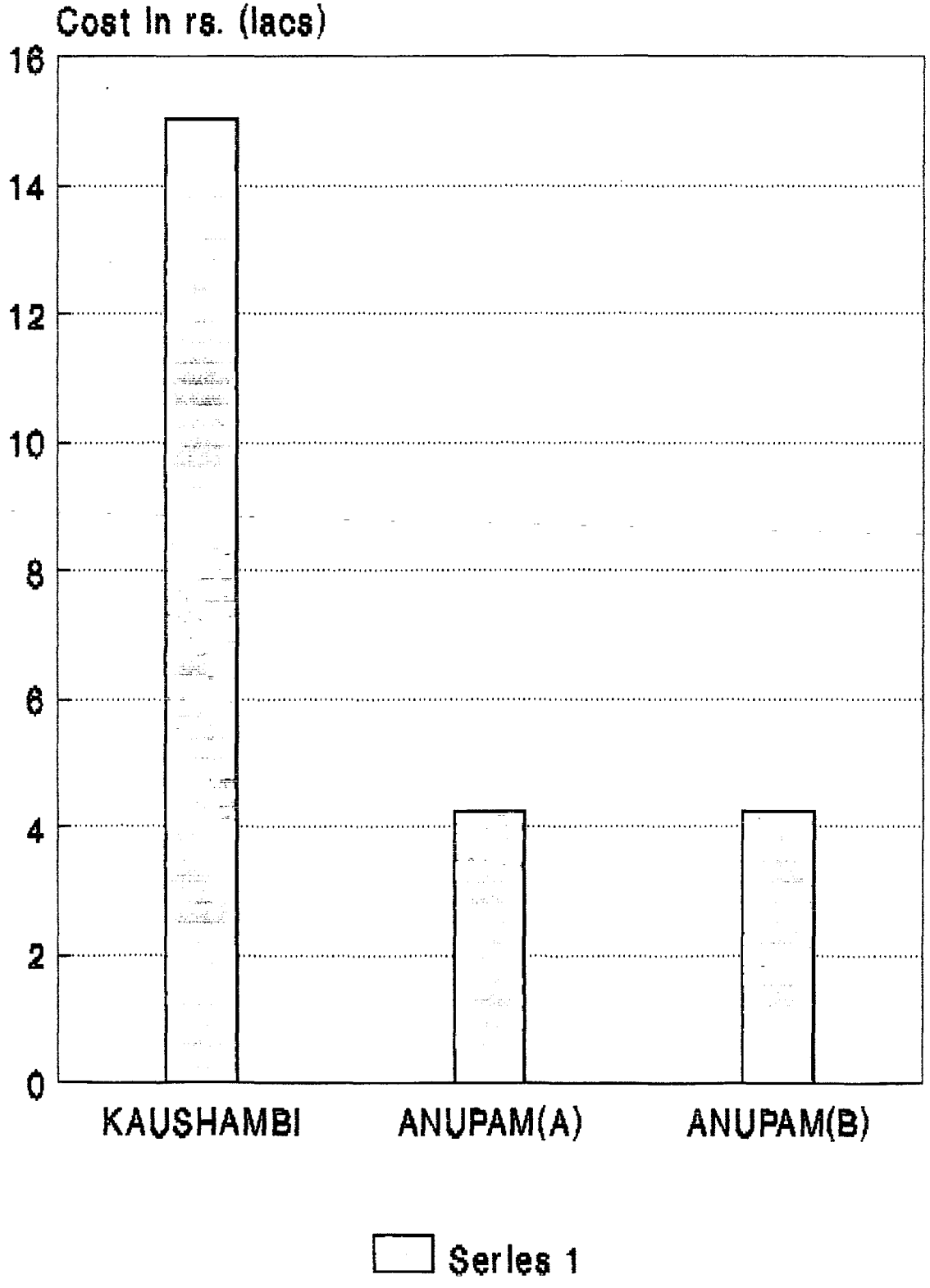
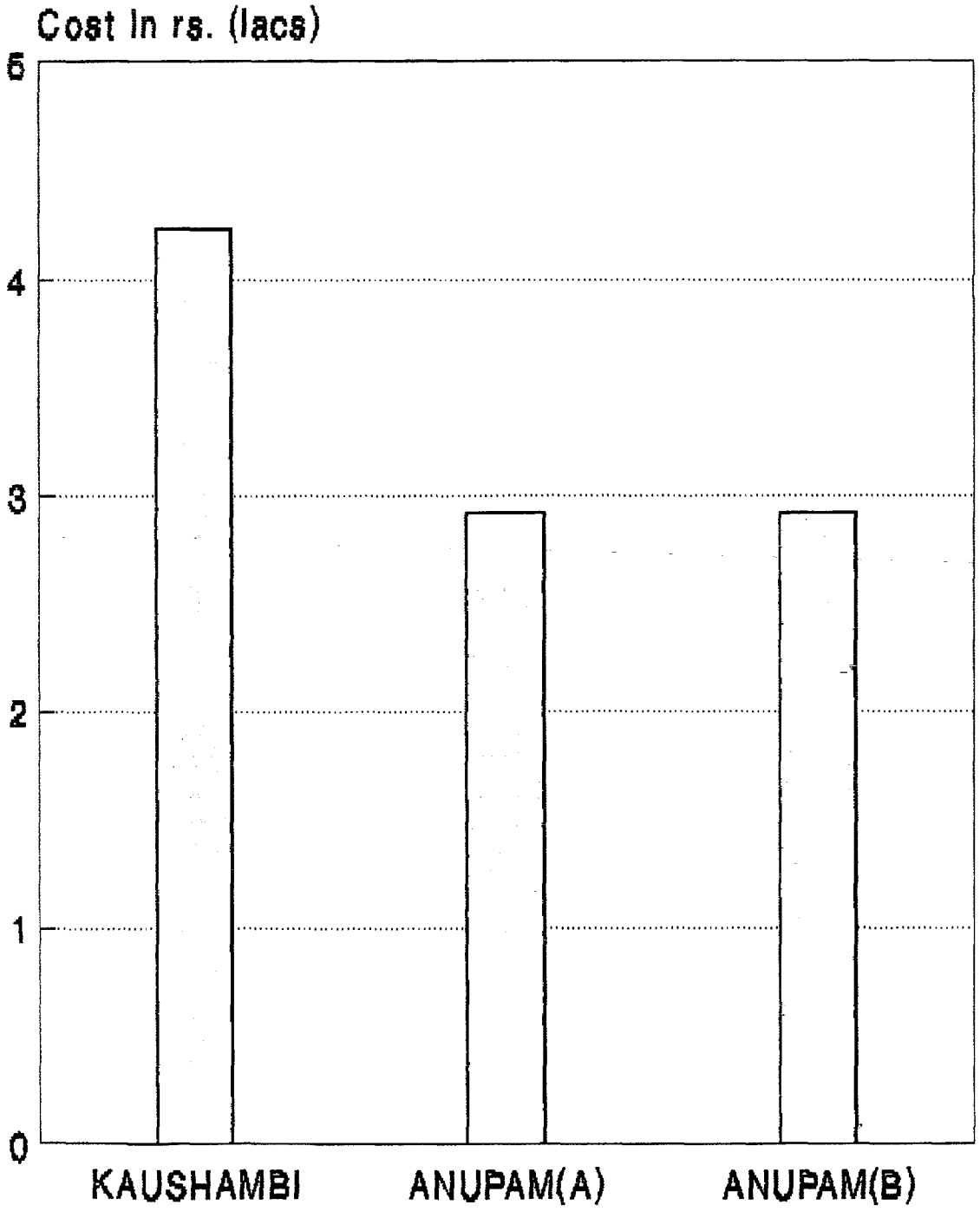
15
10
5
0
KAUSHAMBI
ANUPAM(A)
ANUPAM(B)
Series 1

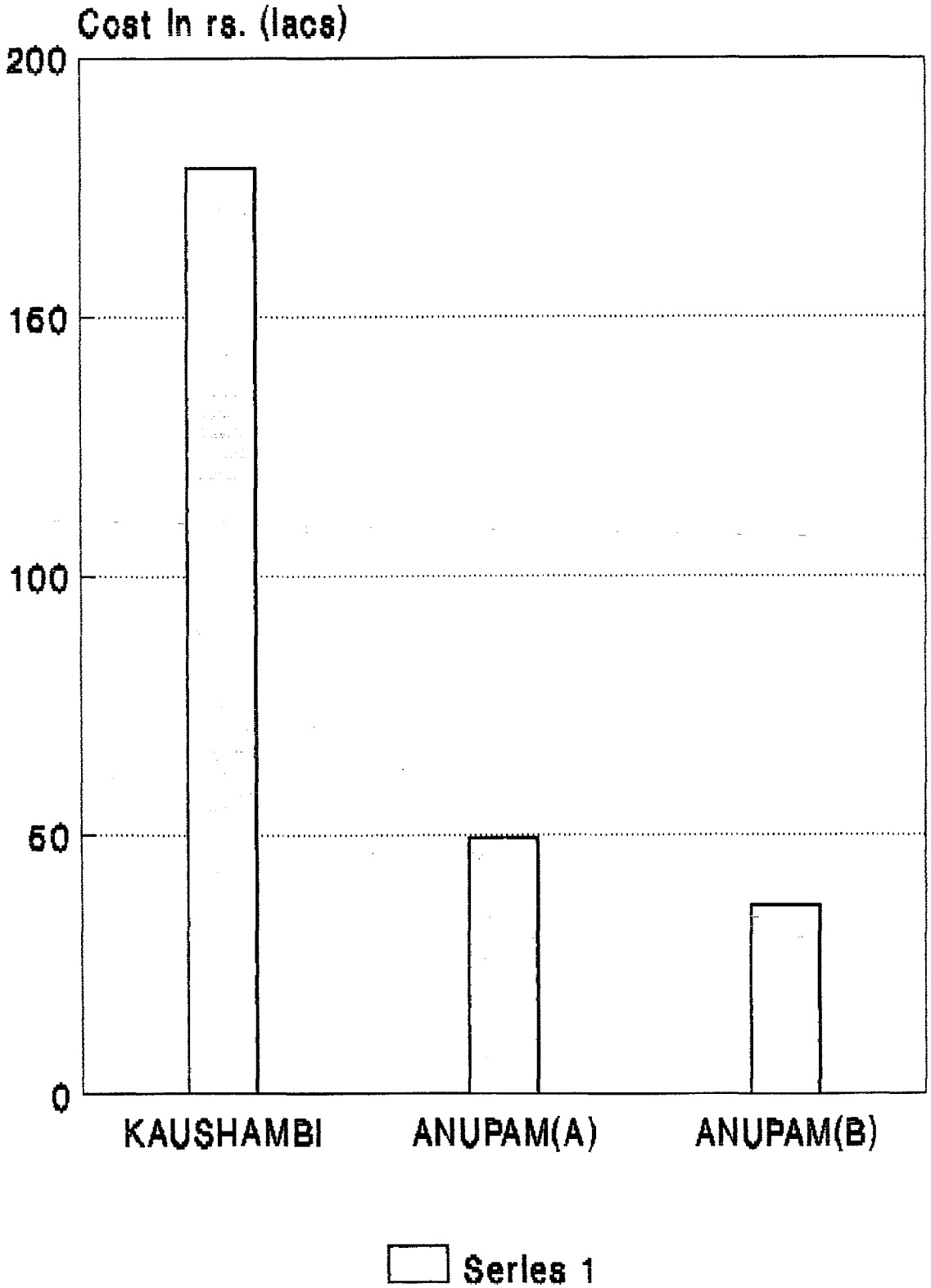
FIRE FIGHTING



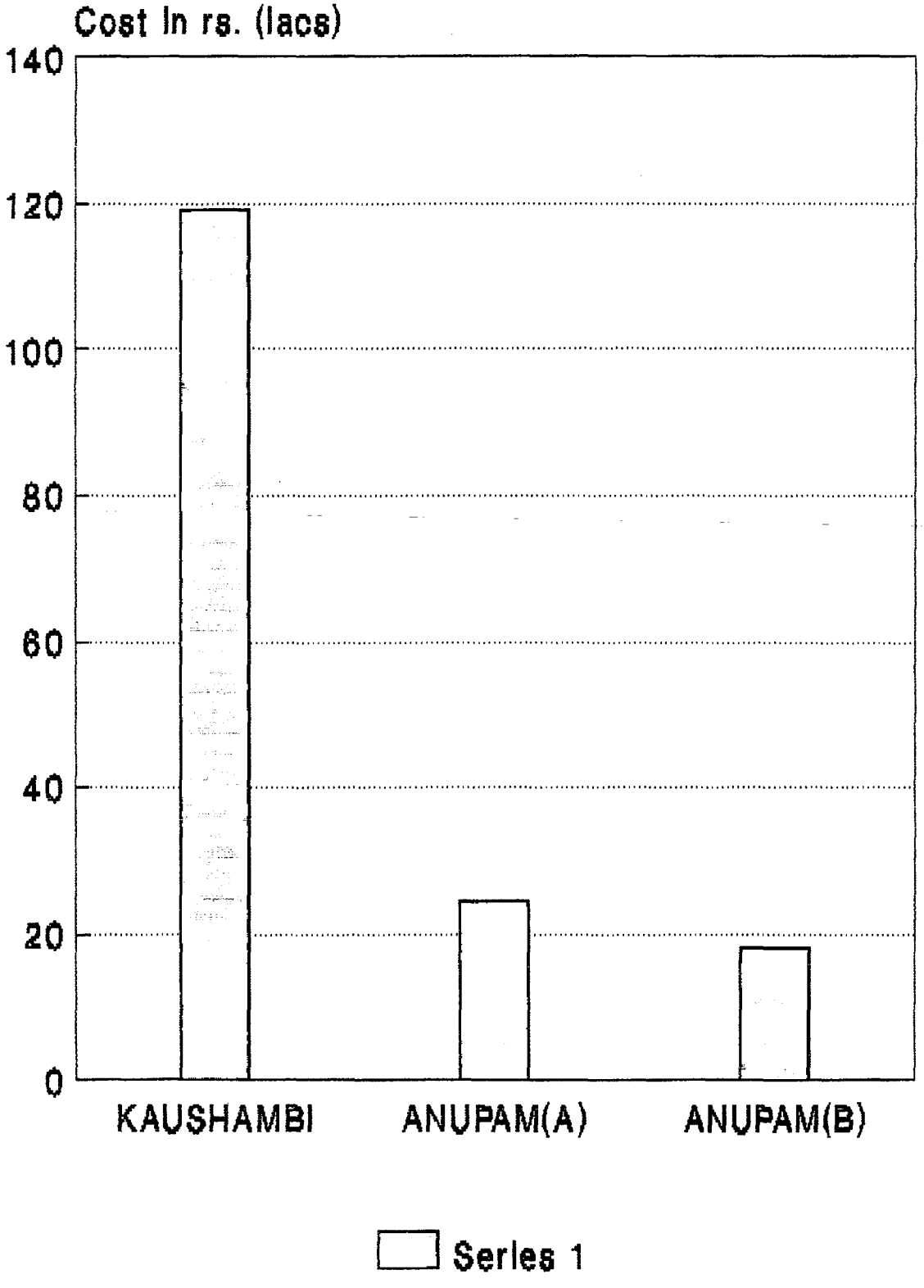
DRAINAGE



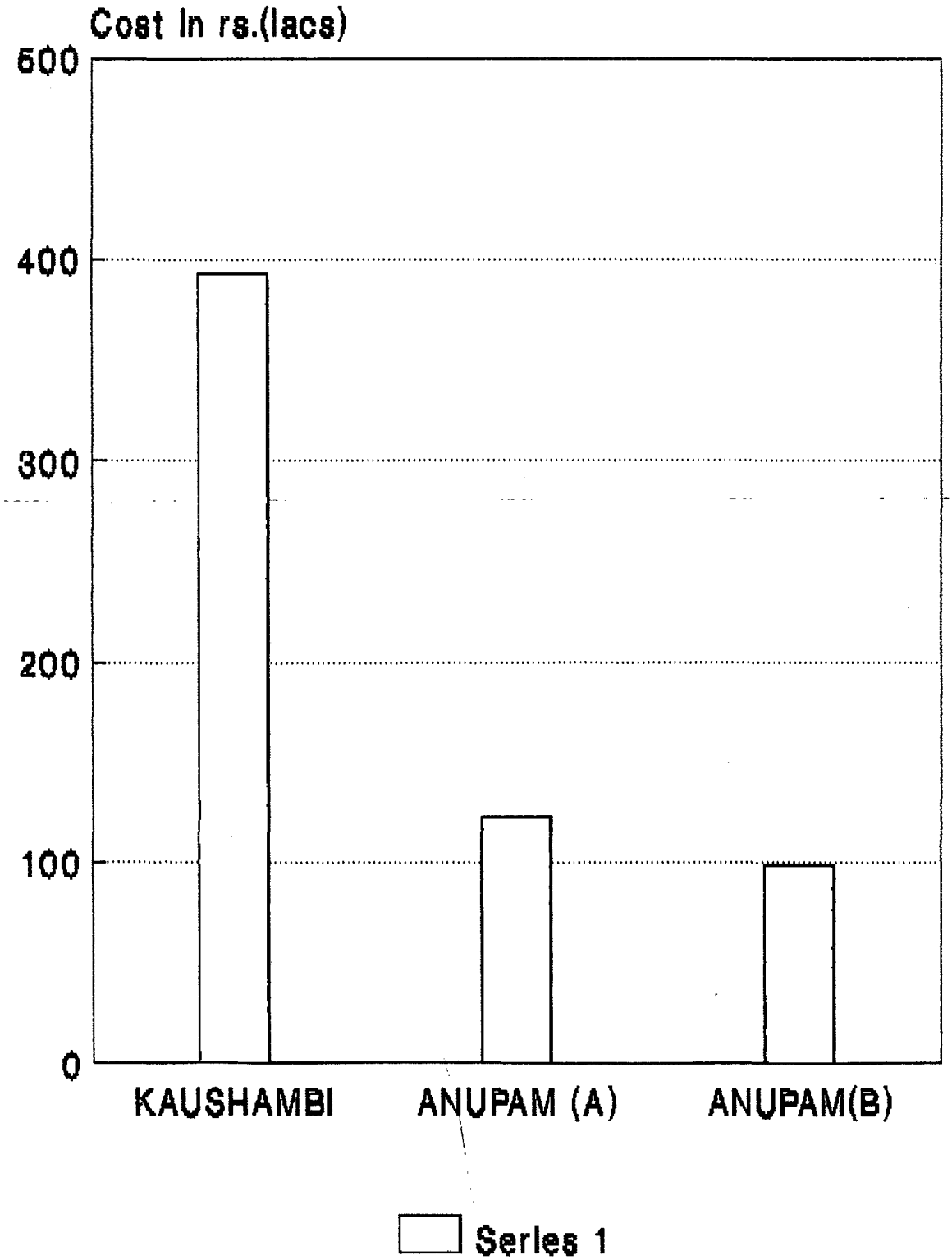
ARCHITECTURAL SYSTEM



STRUCTURAL SYSTEM



TOTAL


Cost In rs.(lacs)
600
400
300
200
100
0
KAUSHAMBI
ANUPAM (A)
ANUPAM(B)
Serles 1

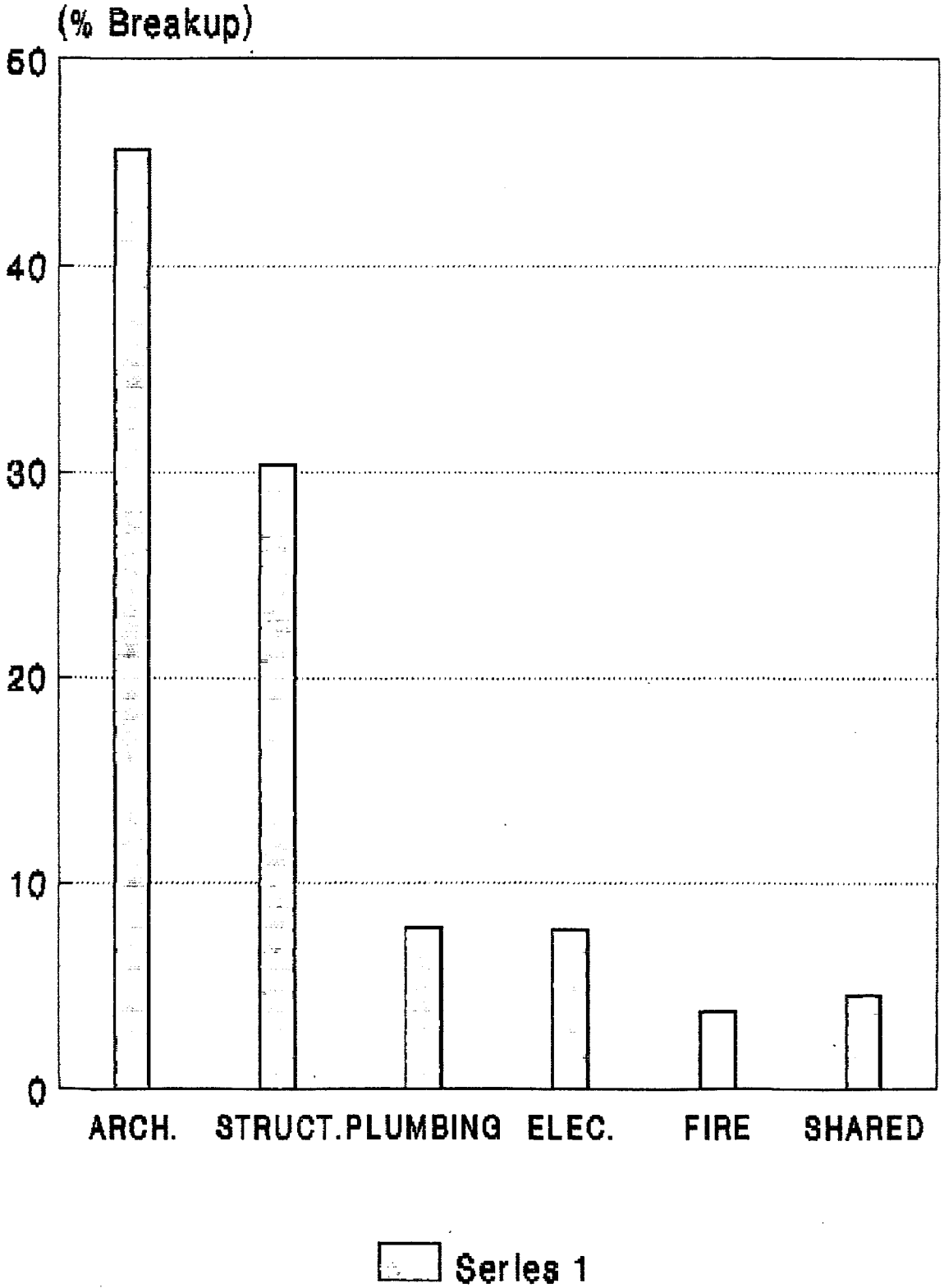
COST BREAK UP OF BUILDING SYSTEMS (IN RS)

S.No.		Kaushambi	Anupam Type A	Anupam Type B
1.	Architectural system	1,78,87,605	48,58,702	36,78,726
2.	Engineering systems			
	(a) Structural	1,19,11,705	24,61,110	18,23,000
	(b) Plumbing	26,93,890	11,44,000	9,10,000
	(c) Electrical	30,24,988	12,41,500	9,75,000
	(d) Fire fighing	15,05,000	4,25,000	4,25,000

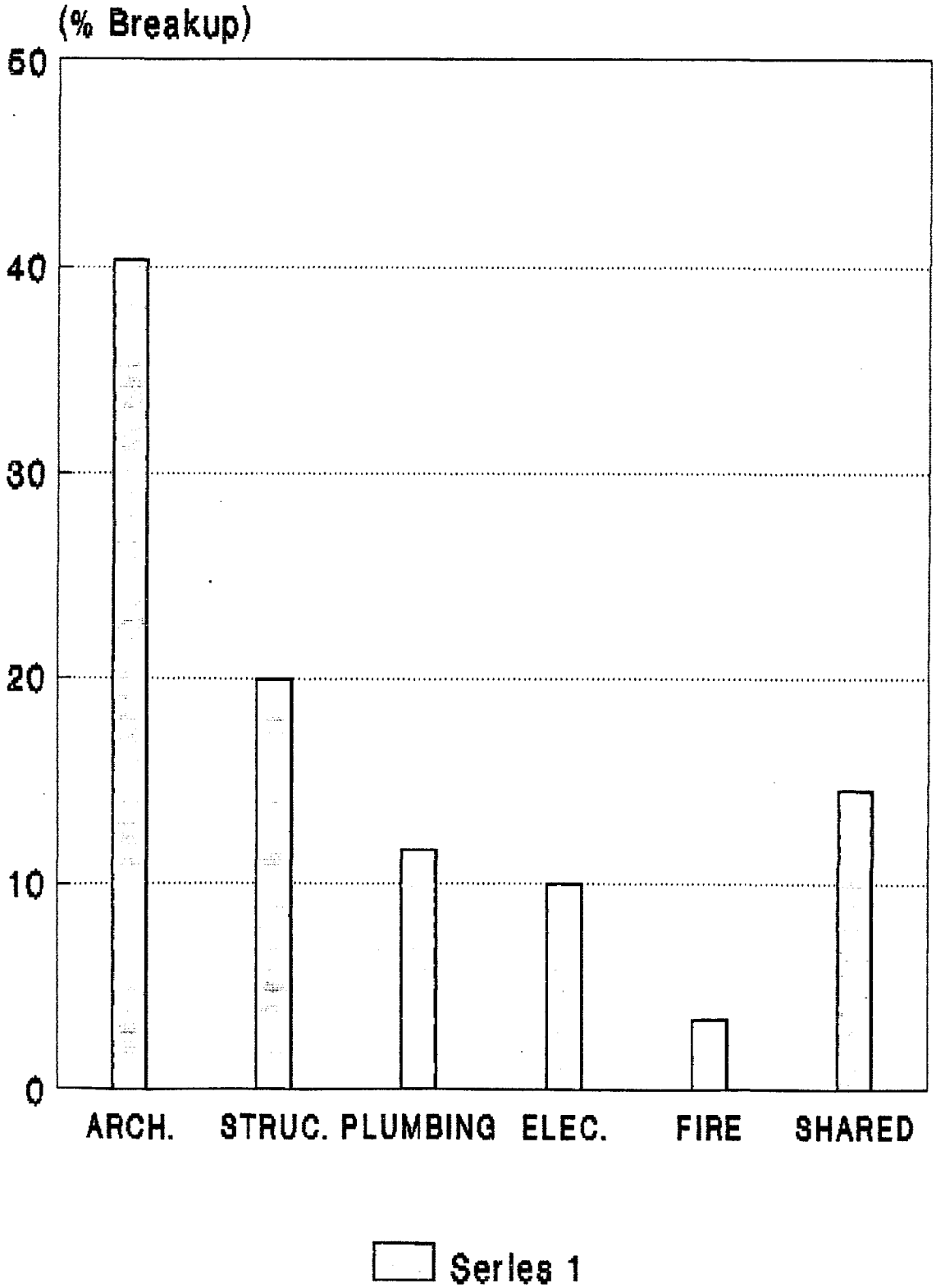
COST BREAK UP OF BUILDING SYSTEMS (%)

S.No.		Kaushamby	Anupam Type A	Anupam Type B
1.	Architectural system	45.6	40.3	37.4
2.	Engineering systems			
	(a) Structural	49.8	45.2	44.5
	(b) Plumbing	7.9	11.6	12.1
	(c) Electrical	7.7	10.0	10.1
	(d) Fire fighting	3.8	3.4	4.1
3.	Shared system	4.6	14.5	18.1

KAUSHAMBI


(% Breakup)
60
40
30
20
10
0
ARCH.
STRUCT.
PLUMBING
ELEC.
FIRE
SHARED
Series 1

ANUPAM (A)


(% Breakup)
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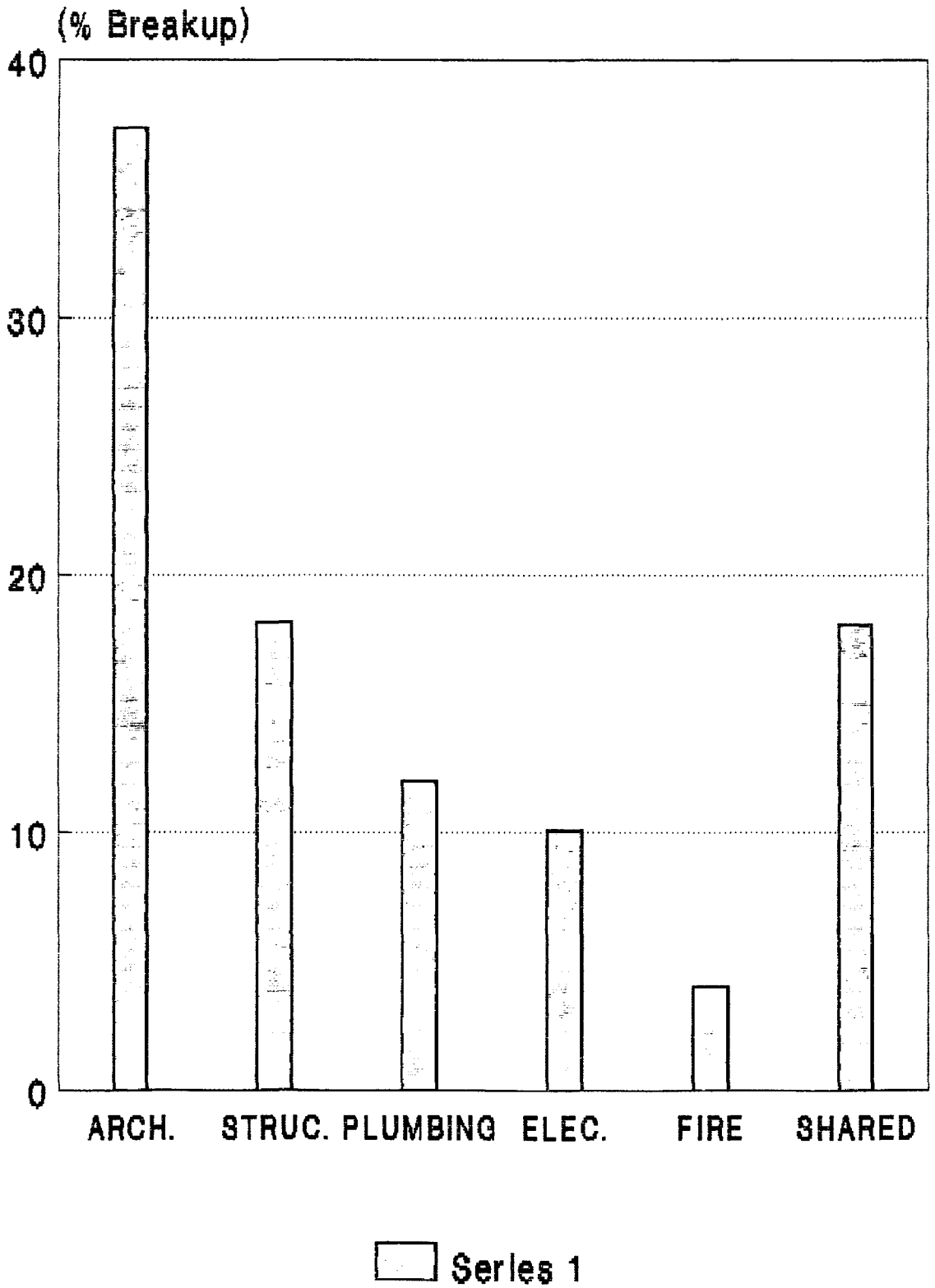
40
30
20
10
0
ARCH.
STRUC.
PLUMBING
ELEC.
FIRE
SHARED
Series 1

ANUPAM (B)


(% Breakup)
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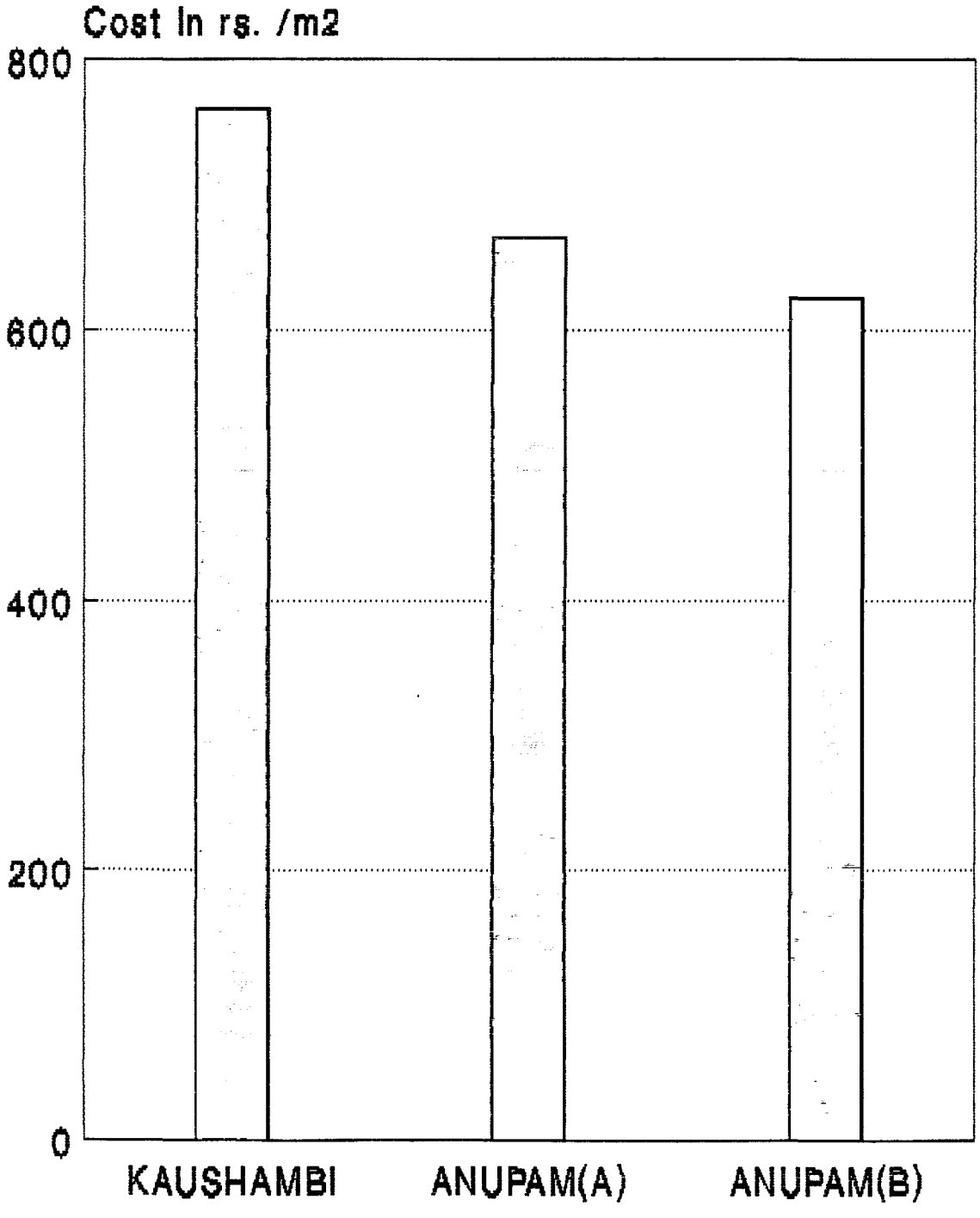
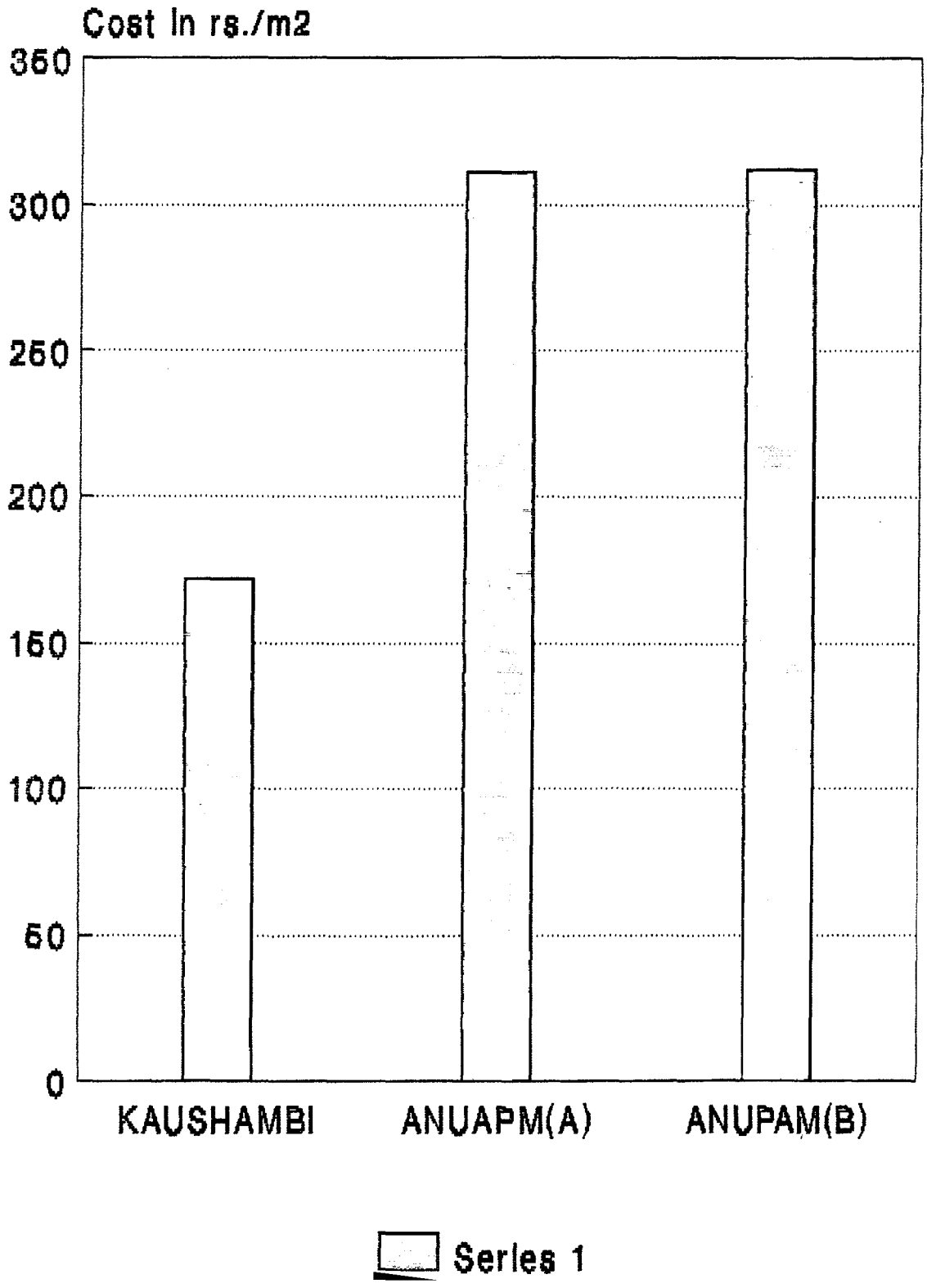
30
20
10
0
ARCH.
STRUC.
PLUMBING
ELEC.
FIRE
SHARED
Series 1

STRUCTURAL SYSTEM



PLUMBING


Cost In rs./m2
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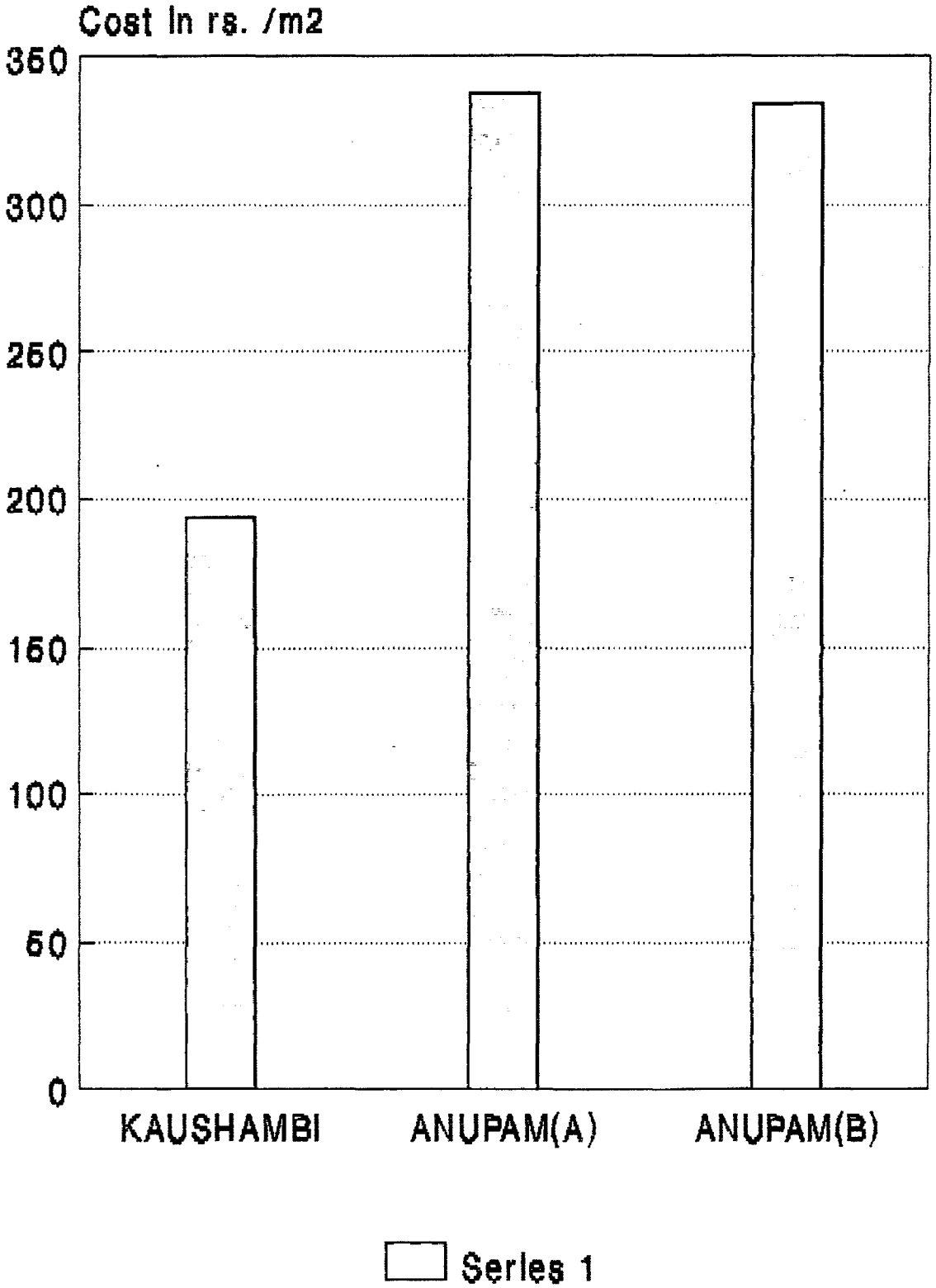
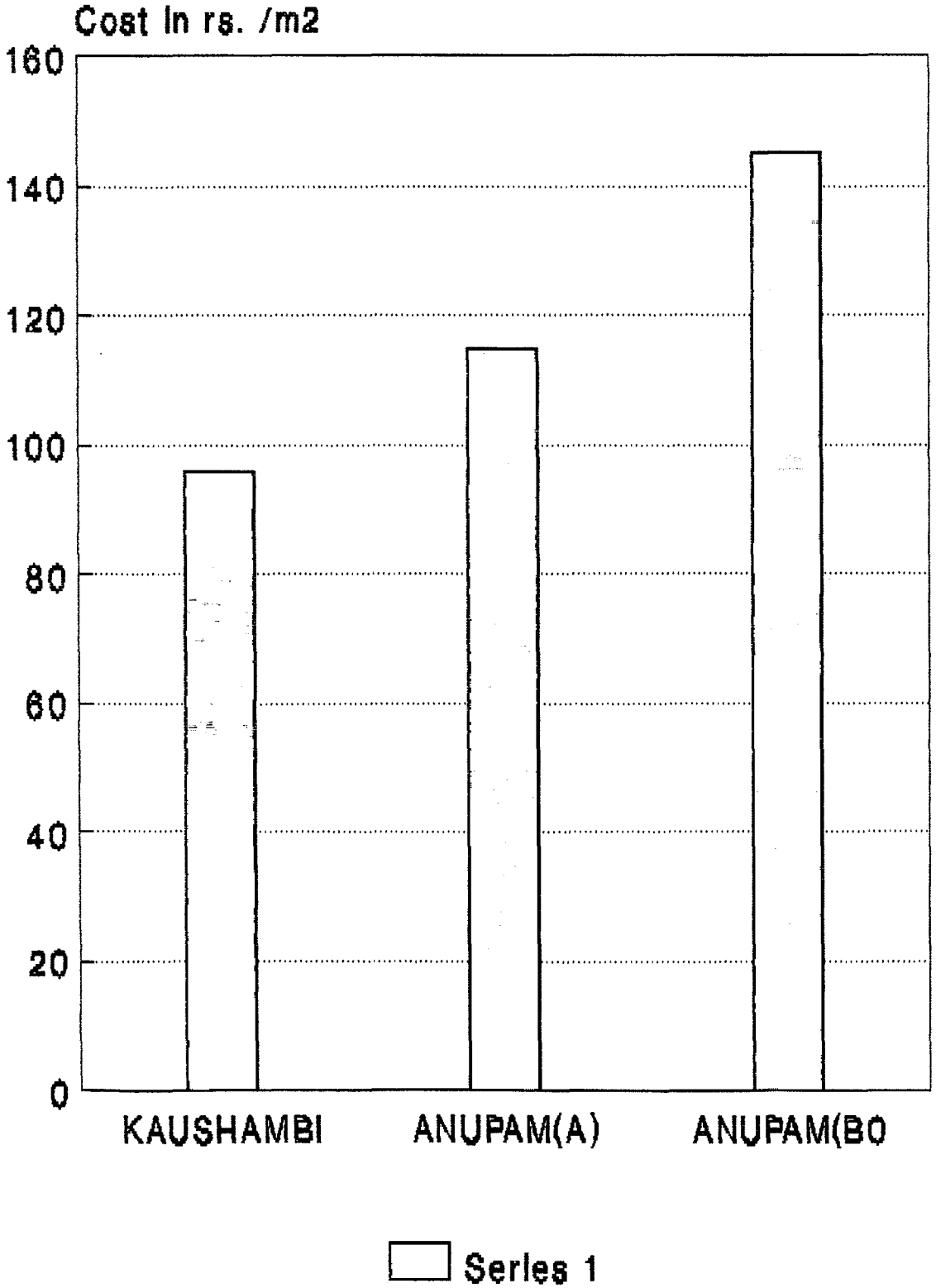
300
250
200
150
100
50
0
KAUSHAMBI
ANUAPM(A)
ANUPAM(B)
Series 1

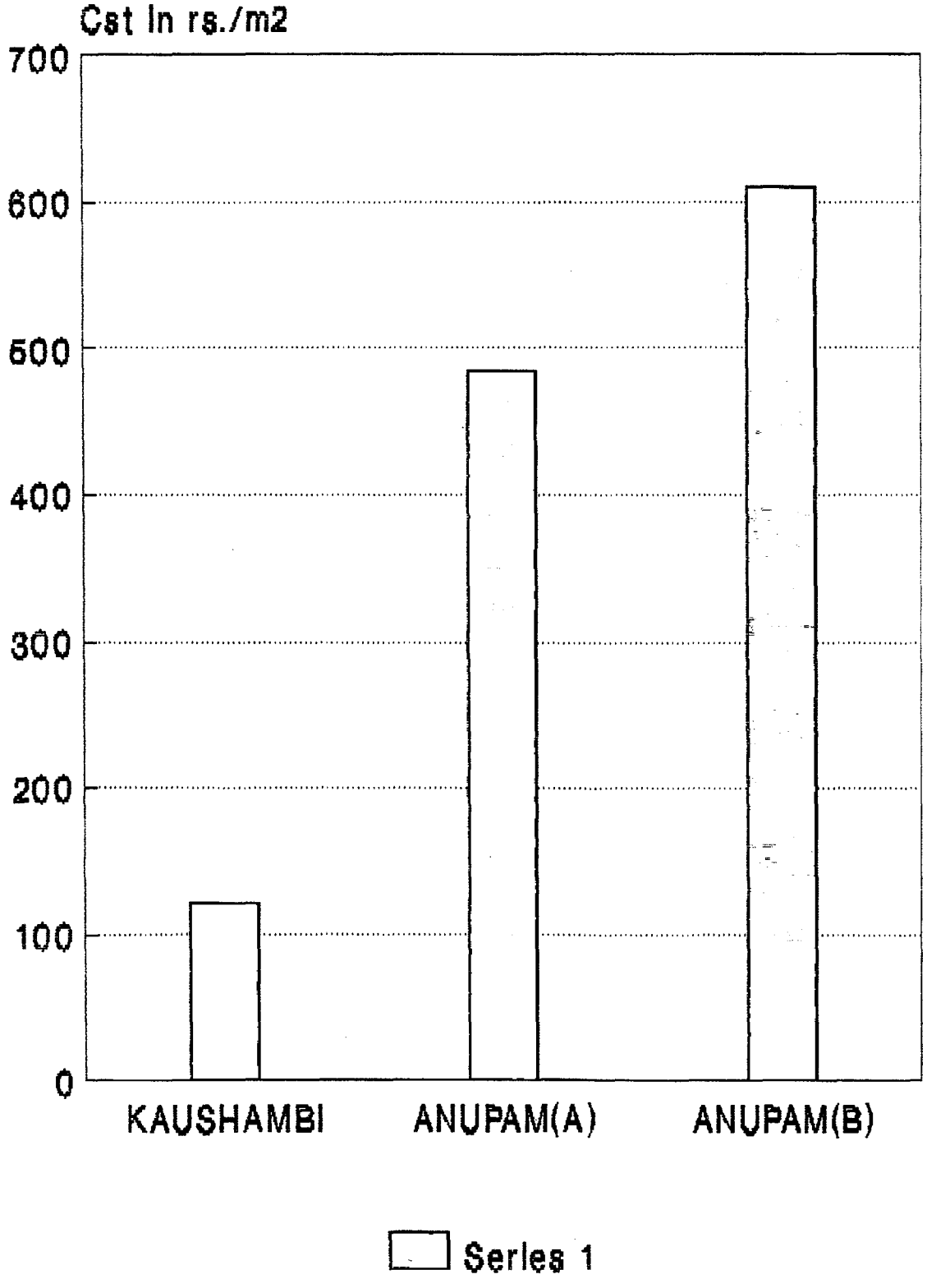
ELECTRICAL


Cost in rs. /m2
350
300
250
200
150
100
50
0
KAUSHAMBI
ANUPAM(A)
ANUPAM(B)
Series 1

FIRE FIGHTING



SHARED SYSTEM



CHAPTER 4

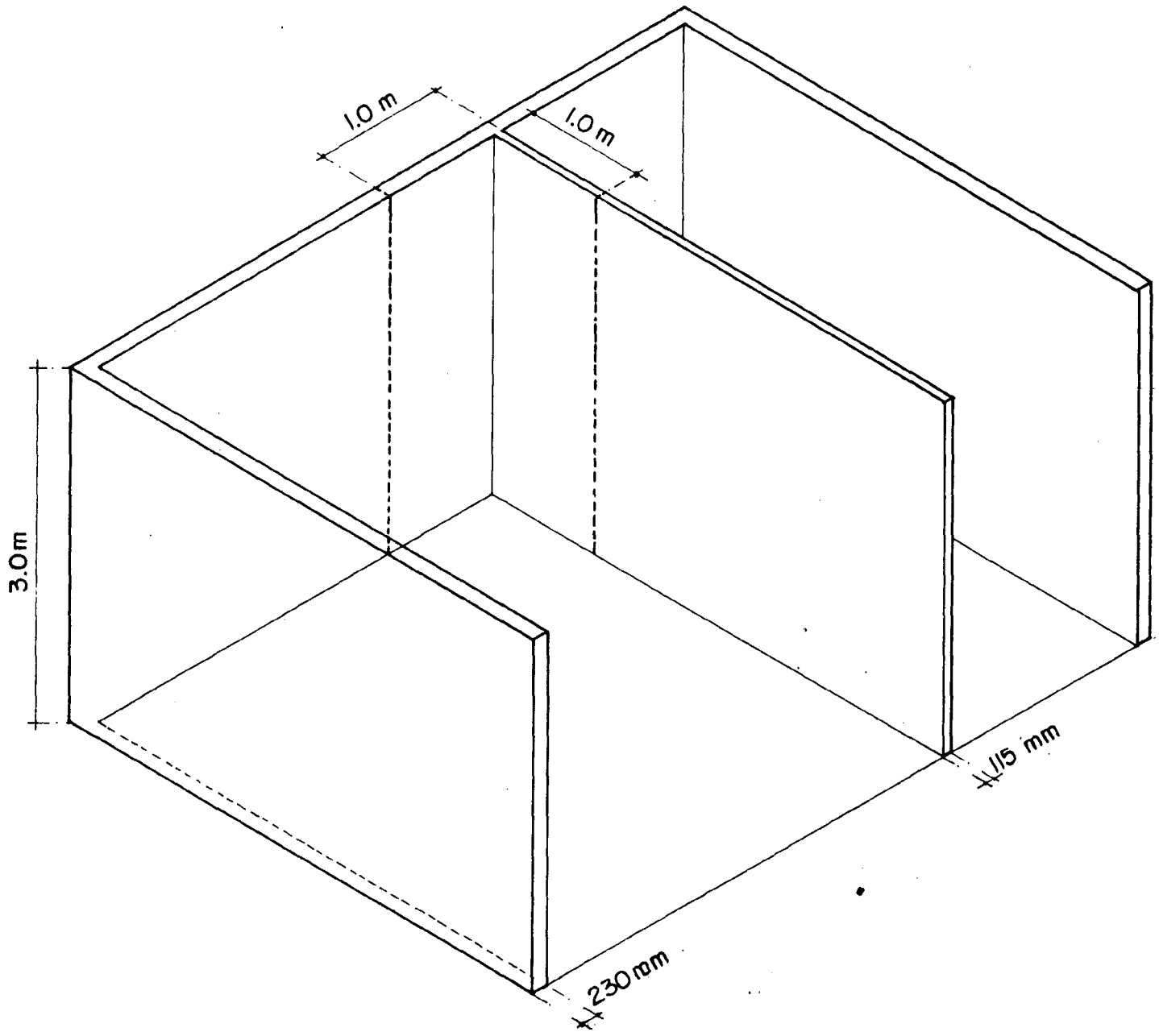


Fig. 7 PLAN, SIZE V/S PERIMETER COSTS

CHAPTER 4 - ANALYSIS OF CONSTRUCTION COSTS

4.1 IMPACT AND ANALYSIS OF PLAN CONFIGURATION ON THE CONSTRUCTION COST

4.1.1 Plan Shape V/s Perimeter Costs

As the plan shape tends to move from simple to complex its perimter length increases accordingly.

For the same covered area of the residential unit the shape of the enclosure may vary. Barring the geometrical figure of a circle, the maximum floor area enclosed in least perimeter is in a square and it tends to decrease with the increased rectangular or irregular aspect of the figure.

For a unit length of a wall of floor to floor height = 3 meters (refer diagram) enclosing a given space the cost calculation for an external 9" thickness brick wall and an internal 4½" brick wall is as follows :

S.No.	Item	Rate	Qty.	Amount
1.	External wall 9" thickness			
(a)	Brick work with brick of class designation 75 in cement mortar (1.6) in super structure above plinth to floor 2 level	866.3 + 33.4		

- Extra for brick work in super structure above ft. level 2	32.35		
(b) Plastering			
- 15 mm cement plaster on rough side of single or hlaf brick wall (1:6)	29.65	3 m^2	89.00
- 15 mm cement plaster on rough side of single or half brick wall (1:3)	43.45	3 m^2	130.30
(c) Finish			
- Colour washing in green blue or buff to a given even shade on new work (2 or more coats) with a base of coat of white washing	2.9	3 m^2	8.70
- Finishing external surface with washed marble chips of approved shade 3-6 mm size laid in ordinary greay cement inclusive of rubbing and making grooves	225	3 m^2	675.00
(d) Total			1,546.52
2. Internal Wall 4½" thick			
(a) Half brick masonary with brick of class designation 75 in super structure upto level 2	122.75		

- External above floor 2 level	3.7		
- Extra for providing and placing in position 2 nos. 6mm dia M.S. bars at every third course of half brick work	26.25	3 m^2	
	152.70		458.10
(b) Plastering			
- 15 mm cement plaster on the ough side of half bricks wall(1:6)	29.65	3 m^2	89.00
- 12 mm cement plaster (1:6)	25.15	3 m^2	75.40
(c) Finish			
Colour washing on either sides as in 9" walls	2.9	3 m^2	8.70
(d) Total			640.00

As can be seen from the comparative cost analysis of the external 9" wall and internal 4½" wall the difference between the cost of construction between the two unit length

= Rs. 1,546.52 - Rs. 640.00

= Rs. 906.52/m

Hence, on a comparative basis with the given specification of the assumed work the cost of constructing as external 9" thickness brick wall is 2.42 times the cost of 4½" internal wall.

4.1.2 Plan Size V/s Perimeter Costs

As the size of each unit increases the corresponding increase in perimeter is not in direct proportion on a 1:1 basis. The subsequent costs of external (peripheral) walls as calculated in section 4.1.1 when divided by the area of the unit on a per sq.ft. basis is reduced.

The same is applicable for the internal walls also.

DERIVING FROM THE CASE STUDIES

	Anupam Type B	Anupam Type A	Kaushambi
Area of each unit m^2	90 (1.0)	115 (1.28)	127.5 (1.42)
Perimeter walls (m/m^2 netarea)	0.39 (1.0)	0.43 (1.1)	0.435 (1.12)

From these figures, it can be compared that for an increase of 1.28 times in area, the corresponding increase in the perimeter is 1.1 times only, i.e. by a factor of 0.85. Similarly for an increase of 1.42 times in the area of the perimeter is 1.12 times, i.e. by a factor of 0.79.

4.1.3 Circulation Space

The impact of shape and size of the unit V/s perimeter costs have been analysed in 4.1.1 and 4.1.2. Alongwith

these two aspects the grouping of individual units of each floor, i.e. the number of units on each floor viz-a-viz the circulation area becomes crucial. When the costs for circulation area cum the conveying system is equally divided by the units on each floor the increased numbers of units on a floor reduces the cost of shared facilities/flat considerably.

Deriving the case studies :

	Anupam TypeB	Anupam Type A	Kaushambi
Area of each unit, m^2	90	115	127.5
Net area (m^2)	360	460	765.0
Circulation area (m^2)	56.53	64	153.7
Gross area (m^2)	416.50	524	917.8
Circulation area as a percentage of gross area	13.6%	12.2%	16.7%
Circulation area as a percentage of net area	15.7%	13.9%	21.2%
Circulation area/ flat (m^2)	140	16	25.6

i.e., for the same numbers of units, i.e. four, an increase in the flat size has brought a corresponding increase in the circulation area in absolute terms but as a percentage of the net area a decrease is observed.

Hence, the costs incurred/flat on a per meter square basis is less.

(The variation of list costs alongwith height has been dealt with in section 4.2.2).

Taking the case of 2 lfts in the core and 4 flats to a floor V/s 6 lifts to a floor at a floor level G+7 the comparative costs/flat have been analysed below :

	'A'	'B'
Cost of 2 lifts/ flats (Rs)	61,130	40,952
Circulation area/ flat	16 m^2	25.6 m^2
Increase in circulation area (Corridor area)	=	10 m^2

4.2 IMPACT AND ANALYSIS OF HEIGHT ON CONSTRUCTION COSTS

Here the analysis is dependent on number of floors and overall height.

4.2.1 Height V/s Structural System

The variation in the different components of the structural system :

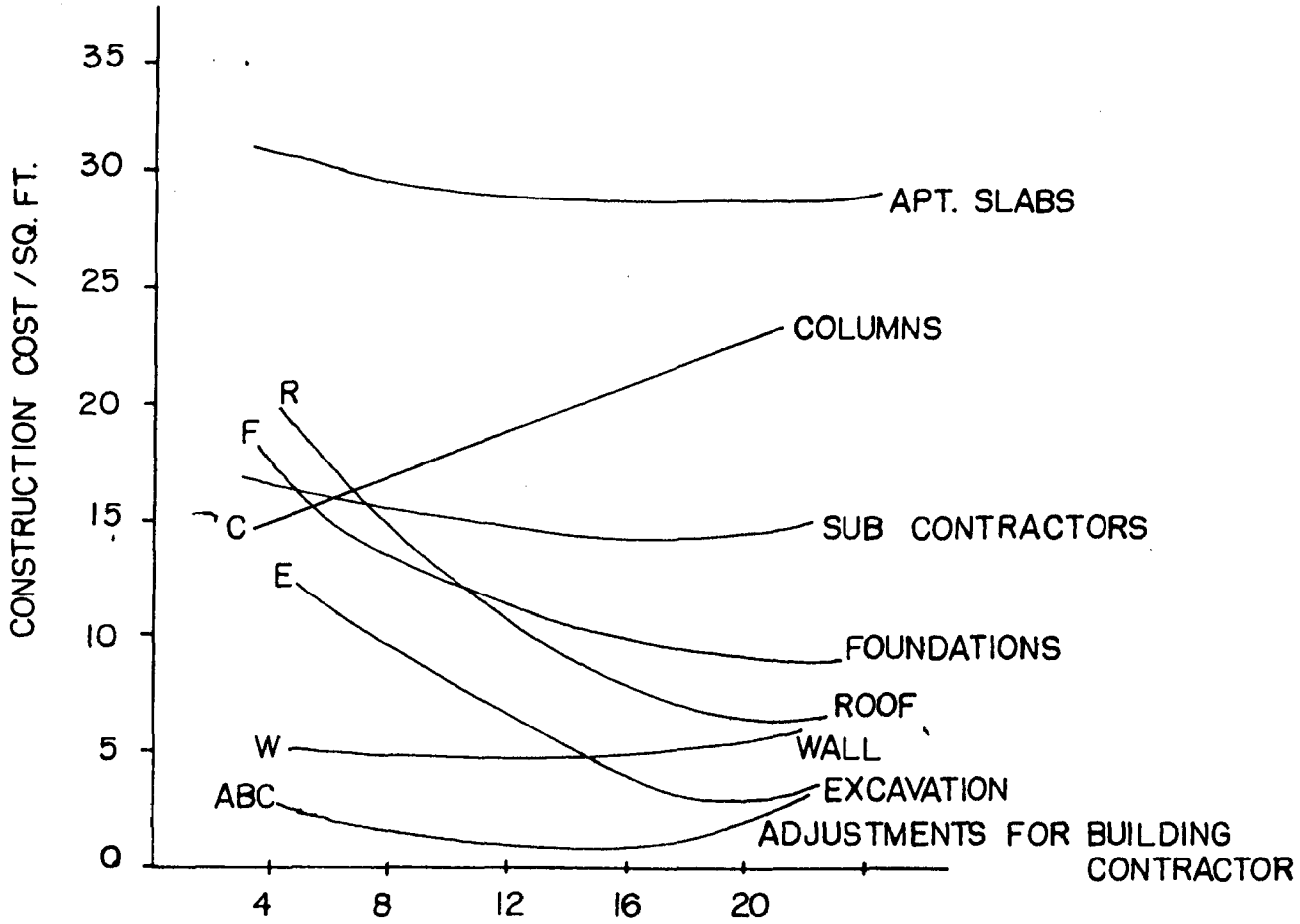


Fig. 8 Variation of elements of Structural Cost with Height

* Foundation
* Floor slabs
* Beams
* Columns
* Walls

alongwith height have been seen through the case studies.

Figure shows the variation of the cost/sq.ft. of the component with increase in height.

For all R.C.C. work above floor level two and excluding the cost of reinf. and extra of Rs. 32.25/m^3/floor is added to the rate of the item to acquire at the rate for that particular floor.

4.2.2 Conveying System

Vertical movement in the building is achieved through

* Lifts
* Stairs

1. Lifts

As the storage height of the building moves beyond G+3, lifts are installed for easy movement.

At the fourth floor level the cost of installation of lifts including :

* Machine Room
* Machinery

* Car, guide rails
* Rope, weight etc.

works out to be approx. Rs. 8,10,000.00

* Cost of R.C.C. lift shaft and reinforcement for the joint G+4 level = Rs. 20,000/- (excluding cost of foundation).
* For every additional floor the cost of the same works out to be Rs. 5,000/- floor.
* Cost of rope, door, installation of lift for every additional floor Rs. 5,000/-
* Total cost of installation Rs. 10,000/- floor.

On the basis of the above given data, the heightwise variation of the cost of a lift is given in a table on next page.

HEIGHTWISE VARIATION OF COST OF A LIFT

Floor Level	Cost of Lift Installation	Cost/flat (4 units/ floor	Cost/flat (6 unit/ floor
G+4	8,30,000/-	÷ 16 = 51,875/-	÷ 24 = 34,583/-
G+5	8,40,000/-	÷ 20 = 42,000/-	÷ 30 = 28,000/-
G+6	8,50,000/-	÷ 24 = 35,417/-	÷ 36 = 23,611/-
G+7	8,60,000/-	÷ 28 = 30,715/-	÷ 42 = 20,476/-
G+8	8,70,000/-	÷ 32 = 27,188/-	÷ 48 = 18,125/-
G+9	8,80,000/-	÷ 36 = 24,444/-	÷ 54 = 16,296/-
G+10	8,90,000/-	÷ 40 = 22,250/-	÷ 60 = 14,833/-
G+11	9,000,000/-	÷ 44 = 20,455/-	÷ 66 = 13,636/-
G+12	9,10,000/-	÷ 48 = 18,955/-	÷ 72 = 12,638/-
G+13	9,20,000/-	÷ 52 = 17,692/-	÷ 78 = 11,795/-
G+14	9,30,000/-	÷ 56 = 16,607/-	÷ 84 = 11,072/-
G+15	9,40,000/-	÷ 60 = 15,667/-	÷ 90 = 10,444/-
G+16	9,50,000/-	÷ 64 = 14,845/-	÷ 96 = 9,896/-

2. Stairs

Taking a flight of stairs between 2 consequent floors of flight width = 1.2 m, Tread = 25 cm, Riser = 15 cm and midlanding of 1.5 m width as shown in the figure. The cost work out as :

		Rate (Rs)	Qty.	Amount (Rs)
1.	R.C.C. work in staricase excluding landings, preparing top surface finishing excldving cost of c/s	1,544.95	1.25 m^2	1,932.0
2.	R.C.C. in midlanding	1,440.20	0.5 m^2	720.00
3.	Cost of c/s			
	- Staircase	60.35	7.5 m^2	453.0
	- Landing	91.25	3.75 m^2	343.0
4.	Reinforcement @ 12 kg/m^2	17/- kg	11.25 m^2	1,240.0
5.	Total			5,848.0

The total cost of stairs at floor level comes to Rs. 5,848.00 and increased at the rate of approximate Rs.60/- for each consecutive floor.

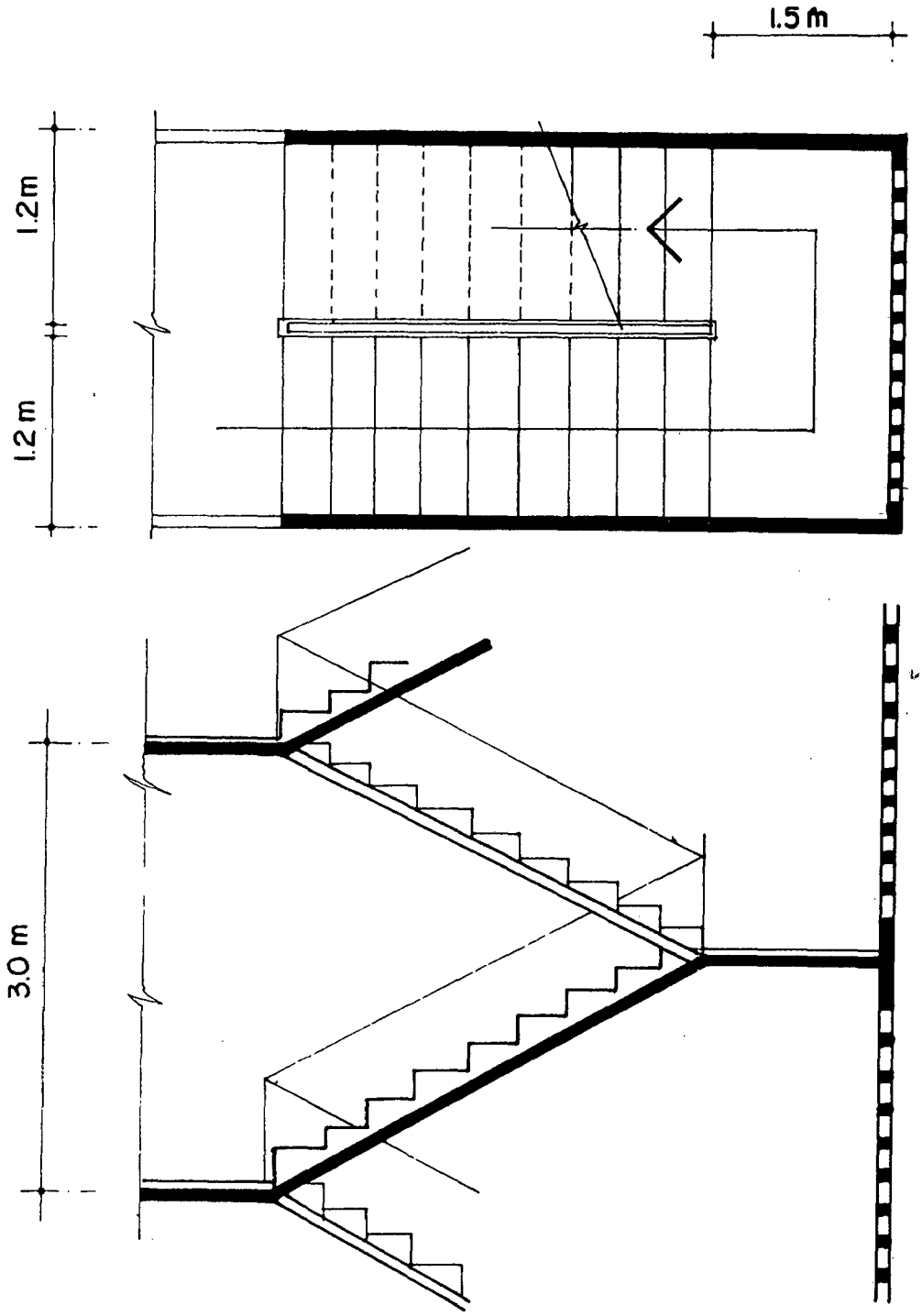


Fig. 9 TYPICAL PLAN & SECTION FOR A STAIRCASE

4.2.3 Plumbing System

Impact of increasing height, number of floors on this system mainly increases the demand of domestic water and fire fighting demand.

As NBC the requirements for residential buildings for domestic water is @ 200 litres/head/day.

So per flat/day = 1,000 litres

According for a 4 unit/floor arrangement the increase/floor = 4,000 litres

Taking a 4 flat/floor building the increase in domestic water demand and water for fire fighting is given as under :

No. of floor	Building height	Domestic water	Fire OHT litre	Fire (U.G.T.) lit.
S+3	12	12,000	-	-
S+4	15	16,000	-	-
S+5	18	20,000	10,000	-
S+6	21	24,000	10,000	-
S+7	24	28,000	10,000	-
S+8	27	32,000	20,000	50,000
S+9	30	36,000	20,000	50,000
S+10	33	40,000	20,000	50,000
S+11	36	44,000	20,000	50,000
S+12	39	48,000	20,000	50,000

S+13	42	52,000	20,000	50,000
S+14	45	56,000	20,000	50,000
S+15	48	60,000	20,000	100,000

The O.H.T. and U.G.T. capacities are thereby affected at certain crucial point such as :

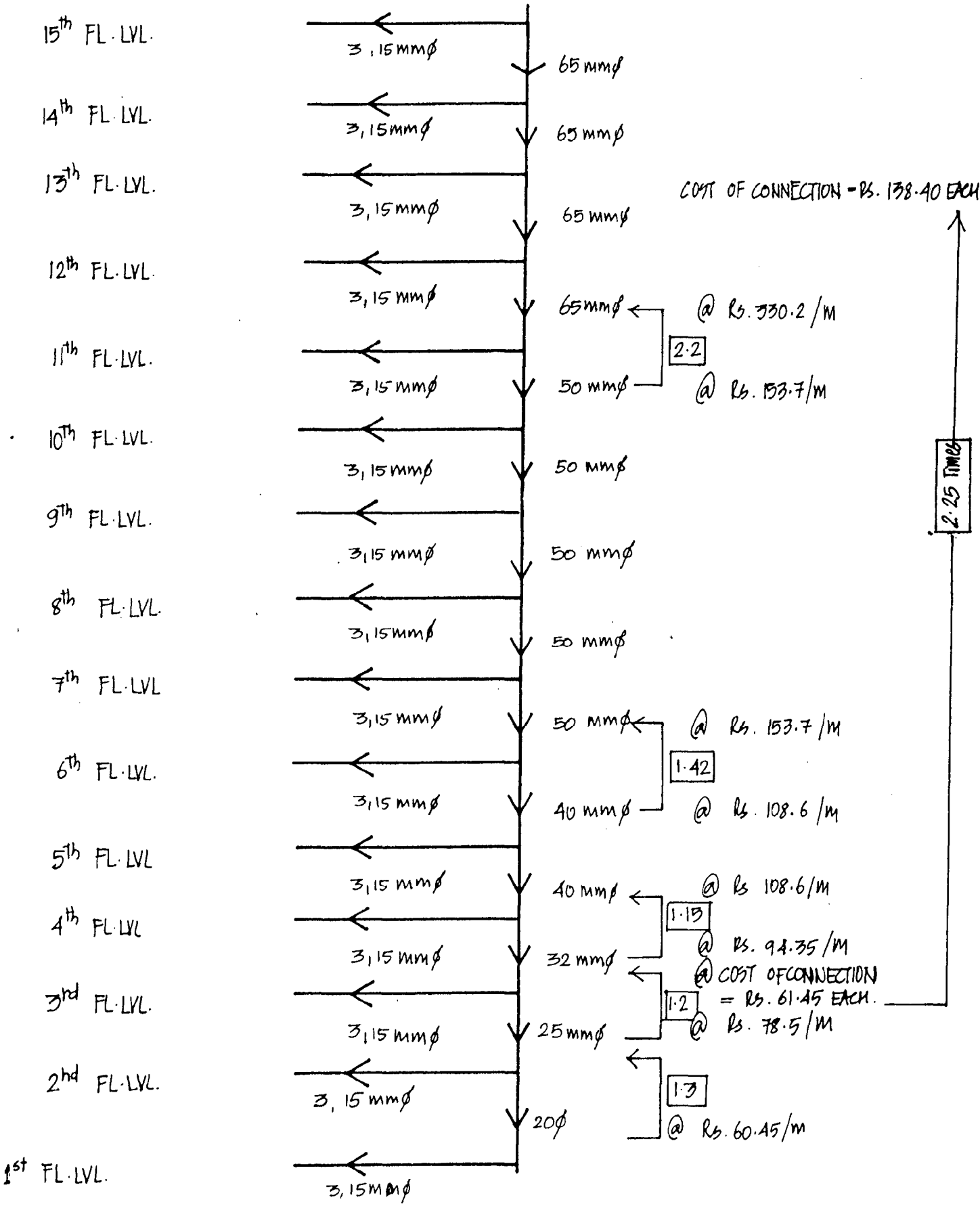
* S+5 where the fire fighting requirements are initiated.
* S+9 where there is a massive jump in U.G.T. capacity.
* S+15 where again the demand for fire fighting in U.G.T. doubles.

For a given design and location of toilet the impact of additional floors on the water supply down take my be analysed on the basis of :

* Cost of connection of 15 mm dia pipe to 20-40 dia main = Rs. 61.45 each.
* Cost of connection of 15 mm dia pipe to 50-80 mm dia main = Rs. 138.40 each.

i.e., an increase of 2.25 times for change of dia of main from 40-50 mm.

* Cost of G.I. pipe providing and fixing complete with fittings and clamps, including cutting and making walls



WATER SUPPLY DOWNTAKE IN 15 STOREYED BLOCK.

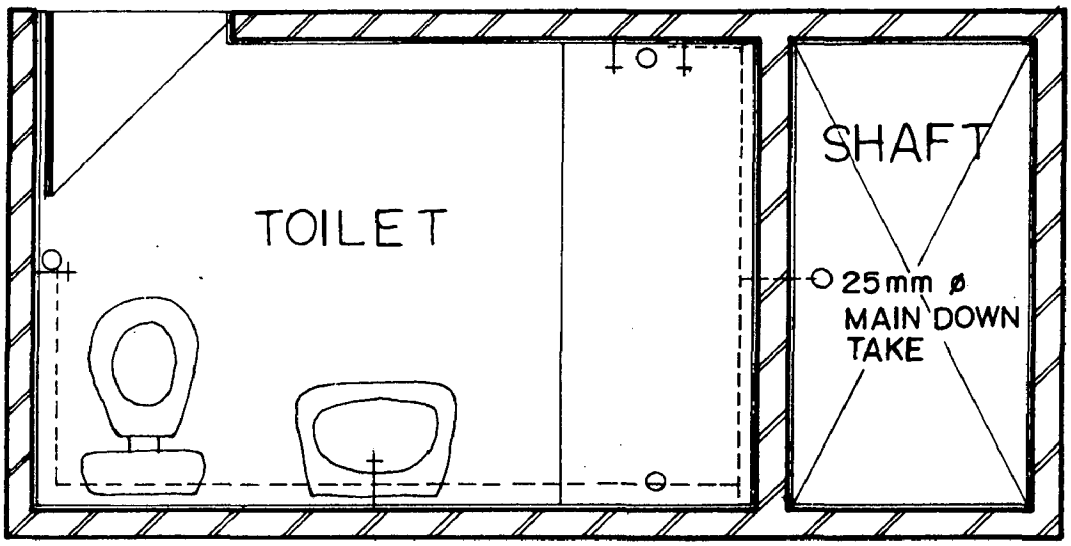


Fig.11

15 mm Ø	...	Rs. 51.40
20 mm Ø	...	Rs. 60.45
25 mm Ø	...	Rs. 78.50
32 mm Ø	...	Rs. 94.35
40 mm Ø	...	Rs. 108.60
50 mm Ø	...	Rs. 153.70
65 mm Ø	...	Rs. 330.20

4.2.4 Architectural System

Most of the costs under this system are mainly affected by plan variation and have been covered therein Section 4.1. Impact of height variation mainly increases the quantity of the items by

= Quantity of item/floor x no. of floors

The excess is mainly in the form of extras for sussessive floors due to carriage, labour and material.

* Extra for brick work in superstructures above floor level two = Rs. 32.35 cum/floor.

* Extra for half brick masonary work above floor level two in superstructure = Rs. 37.00 cum/floor.

4.3 NEW MATERIALS AND TECHNIQUES OF CONSTRUCTION

Apart from the analysis done on the actual design decisions and their impact on costs, certain fundamental decisions can enhance the time factor and ease involved in the actual construction which can ultimately effect the cost of the project.

In this section no detailed analysis is offered, only a brief is given on various systems, techniques and materials which may be adopted.

4.3.1 Construction Management Techniques

Once the design is finalised and the construction about to start it is vary essential to have a construction manager on the team who will detail out the construction phase completely of the entire desired period of construction right from the day one to the completion including all contingencies - material, labour, finance, weather etc. In big projects in which massive towns have been taken a delay can highly inflate the cost with no fault on the part of the designer/architect.

Various methods like CPM - Critical Path Method and PERT - Project Evaluation and Review Techniques are used. And of lately with the advent of computers the whole process is highly efficient.

4.3.2 Use of New Materials

Newer materials have entered the market, either through the research institutions or by their performance abroad and suitability to the Indian conditions. Deviating from the traditional setup or materials can initially cause a set back in terms of infrastructural inputs, training the labour etc. but in the long run the benefits are evident. Hence this has become acceptable to the big business group like the DLF, ANSALS etc.

Some of the new materials being adopted are :

* Aerated cement concrete - for its lightness which reduces the overall loading in multistoreyed buildings.
* Hollow concrete blocks - Same as above plus it saves precious space when used as walling.

4.3.3 Flat Plates

The flat plate is today's most commonly used structural system in apartment buildings, and it offers many advantages.

1. Since columns can be placed where desired, architects are given more design flexibility. There is no need for regular or modular column arrangement.
2. Partitions can be placed without hindrance, and beams do not project below the slab sofit.

3. Since beams are eliminated and reinforcing is of an extremely simple pattern, speed of reconstruction is increased.

4. Reinforcing bars are straight, permitting electrical conduits to be embedded in the slab with ease.

5. A flat unborken ceiling without any furring or additional hung ceiling produces savings of 40 to 50 cents per square foot.

6. A reduction of 8 to 12 inches in floor-to-floor dimensions lowers over-all building height. Result : custs down wind loads bringing about a savings in cost of frame and foundation.

4.3.4 Slip Form Construction

Sometimes called sliding form construction, slip-form might also be considered an 'extrusion' process. Slip-forms have been used for tall, slender structures such as bins, piers, soils, towers, and only recently for shear walls and bearing walls in apartment buildings.

In this system, concrete is placed into forms, and the forms are continuously moved upward around the clock, seven days a week. The rate of movement is so regulated that the forms rise only when the concrete is strong enough to retain its shape and support its own weight.

Slip-forms are moved by hydraulic jacks that ride up on smooth steel rods embedded in the concrete. The working deck, concrete hoppers, finisher's platform, and frequently the crane are attached to and carried by the moving formwork, the average speed of which is 6 to 18 inches per hour.

4.3.5 Shear Walls

To carry gravity loads and to help resist stresses of wind loads and earthquakes, shear walls are employed. The two functions are interdependent : that is, for a shear wall to act efficiently to resist overturning by wind, it must have downward loads acting on it.

But the primary function of the shear wall is to resist lateral forces. It is not economical to use it just to carry the vertical load, a flat plate system with columns does it better and at less cost.

When the apartment floors are staggered, the flat plate or beam-and-slab combination might not work. In this case, shear walls between apartments can be used to good advantage to support the floor slabs spanning one way between the wall.

When architectural design requires that no column projects into rooms, the bearing wall construction offers a solution; the walls also serve as partitions. They can be

reinforced concrete or, for buildings of limited height, of concrete block or brick.

For taller buildings with high wind loads, a large number of shear walls is required. The framing system would consist of load bearing walls and one-way slab or joist construction. Depending on building height, shear walls increase the cost of concrete frame form 6 to 15 percent.

Exposed exterior shear walls may be textured, sandblasted, bushhammered, or painted. These walls, frequently located at the ends of the narrow wings, can best be lined on the inside face with foamed sheets for insulation and as plastering base.

The system provides effective sound insulation between apartments. It improves rigidity, which is especially important in buildings of over 40 stories. Shear walls can be slip formed, thus reducing cost of the wall by as much as 20 percent.

CHAPTER 5

CHAPTER 5 - CONCLUSION AND RECOMMENDATION

Inferences of the analysis have been provided alongwith the analysis itself. As conclusion to the comparative cost analysis and the inferences thereby the following recommendation in the form of guidelines are suggested which can form the framework at the time of decision making to the architect.

1. (i) Plan 'efficiency' can not be decided merely on the basis of net area to gross area of the ratio. Cost sharing of the excessive space and the common facilities - lifts, firefighting is vital. Thus, 4 units to a floor may be more efficient areawise but costwise accommodating more flats/floor is economical.

(ii) The savings achieved on sharing of common facilities decreases (in absulte) on a /flat unit basis with each successive floor. For adding 2 units more to a 4 units/floor plan the savings at G+4 are to the tune of Rs. 29,000/- per unit which gradually comes down Rs. 3,500/- per unit at the G+16 floor.

(iii) Providing more than 6 units to a flat may prove to further reduce the costs but then the circulation may prove to be numbers one and has to be considered alongwith the cost aspect by the designer/architect.

2(i) For the same floor area a simpler plan shape shall result in a lesser enclosing surface area on a m per m^2 of floor area basis. The slight increase in the resulting internal walls is negligible as the cost of construction and finish of a 9" the external brick wall is 2.4 times cost of a 4½" thick internal brick wall.

(ii) Increase in the floor area does not result in a proportionate increase in the length of the perimeter walls and may decrease the length of enclosure on a m/m^2 of F.A. basis.

3. The percentage wise break up of the building systems for multistoreyed apartments may be approximated to :

Architecture system	40%
Structural system	20%
Other engineering system	25%
Shaved system	15%

These figures may hold true for a 6-9 storeyed buildings. A further increase in the storeys brings down the percentage of the conveying/sheved system which is redistributed between the architectural system.

4(i) For the structural system which form about 20% - 25% of the total cost the cost of foundations/m^2 reduces with increased number of floors. Whereas the overall

cost of the frame-beams/columns/slabs shows an increase. Structural design of columns, beams and slabs, i.e. the frame is one of the crucial aspects as major costs are involved and may effect design decisions.

The architect should all the initial stages itself, i.e. sketch scheme stage-consult a structural engineer for a preliminary structural desing/estimate.

(ii) With increase in height the cost/flat for lifts decreases tremendously. The cost of lift installation becomes a crucial parameter at the G+4 floor level as the cost flat shoots up drastically. Above this the saving in cost/flat decreases and hence for the above floors this does not become a major consideration.

(iii) The deamdn of domestic water increases with an increase in the number of units either due to increase in number of flats/floors or increased number of storeys @ 200 litres/head/day. But the water requirements for fire-fighting purpose as/NBC increase the capacity of the overhead tank (O.H.T.) at G+5 level by a 10,000 liters. But at the G+8 a tremendous increase is observed in the O.H.T. volume - 20,000 litres in the underground tank. Other this at G+15 another increase of 50,000 litres for U.G.T. is needed.

(iv) For the water supply down take pipe - the dia of the pipe changes to maintain pressure. This impact on cost is considerable at the 6th floor level and later at 10th-10th-11th-11th floor level. At this stope cost of pipe (including fixing etc.) increases by 2.2 times for each down takes. Also there is a 2.25 times increase in the cost of each connection between downtake 'distribution line'.

(v) Cost of length of distribution pipes increases mainly as a multiple of the number of floors added as does the cost of fittings.

5. For finishes choice of material which requires less maintenance replacement though a higher initial cost is preferable.

6. Increase in rate of R.C.C. work/cum/floor above four level two = Rs. 91.25/cum.

(i) Increase in rate of work/cum/floor above floor level two = Rs. 32.35/cum.

(ii) Increase in rate of half ble. measury above floor level two = Rs. 3.7/m^2.

7(i) for a multistoreyed residential building the decision heights become G+4, G+8, G+15 mainly in terms of left installation + foundations in the first case. Structrual system + firefighting in the second case.

And mainly the structural system in the third case.

(ii) While the floor area of the flat may be a decision of the client, the shape of the plan is of importance, as it is a highly repetitive unit items like wall finish, plastering, brick work are effected as a mulitple.

8. Working with a structural designer at the steetch design stage may help in reducing the cost of the building considerably.

APPENDICES

APPENDIX 1

BILL OF QUANTITIES FOR KAUSHAMBI

Sr. No.	Description	Amount
1.	Earth Work Subtotal	1,44,776.90
2.	Concrete Work Subtotal	1,00,823.80
3.	Reinforced Cement Concrete Subtotal	148,61,490.56
4.	Brick Work Subtotal	14,93,362.34
5.	Wood Work Subtotal	10,72,229.50
6.	Steel Work Subtotal	11,45,209.50
7.	Flooring Subtotal	39,20,277.25
8.	Roofing Subtotal	4,85,343.50
9.	Plastering Subtotal	21,27,875.00
10.	Miscellaneous Works Subtotal	6,74,359.20
	Total	260,01,847.55
	Add 40% over schedule (DSR 1989)	104,00,739.00
	Grand Total	364,02,586.55

Sl. No.	Description of Item	Ref. DSR-89 Item/pg	Quantity	Unit	Rate	Amount
1.	2.	3.	4.	5.	6.	7.
1.	**EARTH WORK**					
1.1	Earth work in excavation over areas (exceeding 30 cms in depth 1.5 m in width, as well as 10 sqm on plan) including disposal of excavated earth, lead upto 50 m and lift upto 1.5 m disposed earth to be levelled and neatly dressed : Soft/loose soil.	2.6/ p-77	5950.00	Cum	8.25	49087.50
1.2	Filling available excavated earth (excluding rock) in trenches, plinth sides of foundations etc. layers not exceeding 20 cm in depth : consolidating each deposited layer by ramming and watering lead upto 50m and lift upto 1.5 m.	2.62/ p-82	2090.00	Cum	5.70	11913.00
1.3	Extra for every additional lift of 1.5 m or part thereof in : Soft/loose soil.	2.27/ p.82	3500.00	Cum	0.95	3325.00
1.4	Disposal of surplus excavated earth by means of mechanical transport including loading, unloading etc. complete for all leads :	1.1 p-70				
	Upto 2 km lead		1550.00	Cum	13.99	21684.50
	2-5 km lead		1550.00	Cum	18.39	28504.50
	5-10 km lead		760.00	Cum	24.64	18726.40
1.5	Filling on plinth with Jamuna sand under floors including, watering, ramming consolidating and dressing complete.	2.28/ p.82	320.00	Cum	36.05	11536.00

1.	2.	3.	4.	5.	6.	7.
2.	**CONCRETE WORK**					
2.1	Providing and laying lime concrete in footings and bases for columns excluding cost of centring and shuttering : with graded brick aggregate 40 mm nominal size and 40% mortar comprising of 1 lime putty : 1 surkhi : 1 fine sand.	4.1 p.88	120.00	Cum	319.10	38292.00
2.2	Providing and laying cement concrete in footings and bases for columns, under floors, excluding the cost of centring and shuttering. 1:4:8 (1 Cement : 4 Coarse sand : 8 Graded stone aggregate 40 mm nominal size).	4.5 p.8	160.00	Cum	390.40	62464.00
2.3	Providing an laying damp-proof course 40 mm thick with cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 nominal size).	4.24 p.95	2.00	Sqm	24.65	49.30
2.4	Applying a coat of residual petroleum bitumen of penetration 80/100 of approved quality using 1.7 kg per square meter on damp-proof course after cleaning the surface with brushes and finally with a piece of cloth lightly soaked in keorsene oil.	4.27 p.95	2.00	sqm	9.25	18.50

1.	2.	3.	4.	5.	6.	7.
3.	**REINFORCED CEMENT CONCRETE**					
3.1	Reinforced cement concrete work in slabs and beams of rafts, footings, bases of columns etc. and mass concrete excluding cost of centring, shuttering and reinforcement : 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	5.1 p.96	1830.00	Cum	573.55	1049596.50
3.2	Reinforced cement concrete in walls (any thickness) including attached pilasters, buttress, plinth and string courses, fillets etc. upto floor two level excluding cost of finishing, centring, shuttering and reinforcement 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	5.2/ p.96	130.00	Cum	588.15	76459.50
(a)	Same as above but for floor (2) to floor (3) level.		2.50	Cum	594.03	1485.08
(b)	Same as above but for floor (3) to floor (4) level.		2.50	Cum	599.91	1499.77
(c)	Same as above but for floor (4) to floor (5) level.		2.50	Cum	605.79	1514.47
(d)	Same as above but for floor (5) to floor (6) level.		2.50	Cum	611.68	1529.20
(e)	Same as above but for floor (6) to floor (7) level.		2.50	Cum	617.56	1543.90
(f)	Same as above but for floor (7) to floor (8) level.		2.50	Cum	623.44	1558.60

1.	2.	3.	4.	5.	6.	7.
(g)	Same as above but for floor (8) to floor (9) level.		2.50	Cum	629.32	1573.30
(h)	Same as above but for floor (9) to floor (10) level.		2.50	Cum	635.20	1588.00
(i)	Same as above but for floor (10) to floor (11) level.		2.50	Cum	641.08	1602.70
(j)	Same as above but for floor (11) to floor (12) levels.		2.50	Cum	646.96	1617.40
(k)	Same as above but for floor (12) to floor (13) levels.		2.50	Cum	652.84	1632.10
(l)	Same as above but for floor (13) to floor (14) levels.		2.50	Cum	658.72	1646.80
(m)	Same as above but for floor (14) to floor (15) levels.		2.50	Cum	664.61	1661.53
(n)	Same as above but for floor (15) to floor (16) levels.		2.50	Cum	670.49	1676.23
(o)	Same as above but for floor (16) to floor (17) levels.		10.00	Cum	676.37	6763.70
(p)	Same as above but for floor (17) to floor 18 levels.		10.00	Cum	682.25	6822.50
3.3	Reinforced cement concrete work in suspended floors, roofs landing and balconies upto floor two level exclduing the cost of centring, shuttering, finishing & reinforcement with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	5.3 p.96	240.00	Cum	577.60	138624.00

1.	2.	3.	4.	5.	6.	7.
(a)	Same as above but for floor (2) to floor (3) level.		110.00	Cum	583.38	64171.80
(b)	Same as above but for floor (3) to floor (4) level.		110.00	Cum	589.15	64806.50
(c)	Same as above but for floor (4) to floor (5) level.		110.00	Cum	594.93	65442.30
(d)	Same as above but for floor (5) to floor (6) level.		110.00	Cum	600.70	66077.00
(e)	Same as above but for floor (6) to floor (7) level.		110.00	Cum	606.48	66712.80
(f)	Same as above but for floor (7) to floor (8) level.		110.00	Cum	612.26	67348.60
(g)	Same as above but for floor (8) to floor (9) level.		110.00	Cum	618.03	67983.30
(h)	Same as above but for floor (9) to floor (10) level.		110.00	Cum	623.81	68619.10
(i)	Same as above but for floor (10) to floor (11) level.		110.00	Cum	629.58	69253.80
(j)	Same as above but for floor (11) to floor (12) level.		110.00	Cum	635.36	69889.60
(k)	Same as above but for floor (12) to floor (13) level.		110.00	Cum	641.14	70525.40
(l)	Same as above but for floor (13) to floor (14) level.		110.00	Cum	646.91	71160.10

1.	2.	3.	4.	5.	6.	7.
(m)	Same as above but for floor (14) to floor (15) level.		110.00	Cum	652.69	71759.90
(n)	Same as above but for floor (15) to floor (16) level.		110.00	Cum	658.46	72430.60
(o)	Same as above but for floor (16) to floor (17) level.		33.00	Cum	664.24	21919.92
(p)	Same as above but for floor (17) to floor (18) level.		34.00	Cum	670.02	22780.68
3.4	Reinforced cement concrete work in shelves upto floor two level excluding the cost of centring, shuttering and reinforcement with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	5.4/ p.7	1.70	Cum	573.55	975.03
(a)	Same as above but for floor (2) to floor (3) level.		1.70	Cum	579.29	984.79
(b)	Same as above but for floor (3) to floor (4) level.		1.70	Cum	585.02	994.53
(c)	Same as above but for floor (4) to floor (5) level.		1.70	Cum	602.23	1023.79
(d)	Same as above but for floor (5) to floor (6) level.		1.70	Cum	596.45	1041.03
(e)	Same as above but for floor (6) to floor (7) level.		1.70	Cum	602.96	1025.03
(f)	Same as above but for floor (7) to floor (8) level.		1.70	Cum	607.96	1033.53

1.	2.	3.	4.	5.	6.	7.
(g)	Same as above but for floor (8) to floor (9) level.		1.70	Cum	613.70	1043.29
(h)	Same as above but for floor (9) to floor (10) level.		1.70	Cum	619.43	1053.03
(i)	Same as above but for floor (10) to floor (11) level.		1.70	Cum	625.17	1062.79
(j)	Same as above but for floor (11) to fllor (12) level.		1.70	Cum	630.91	1072.55
(k)	Same as above but for floor (12) to floor (13) level.		1.70	Cum	636.64	1082.29
(l)	Same as above but for floor (13) to floor (14) level.		1.70	Cum	642.38	1092.05
(m)	Same as above but for floor (14) to floor (15) level.		1.70	Cum	648.11	1101.79
(n)	Same as above but for floor (15) to floor (16) level.		1.70	Cum	653.85	1111.55
3.5	R.C.C. work in chajjas upto floor two level including throating of plastered drip and moulding excluding the cost of centring, shuttering, finishing and reinforcement with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size)	5.5	5.00	Cum	608.10	3040.50
(a)	Same as above but for floor (2) to floor (3) level.		5.00	Cum	614.18	3070.90

1.	2.	3.	4.	5.	6.	7.
(b)	Same as above but for floor (3) to floor (4) level.		5.00	Cum	620.26	3101.30
(c)	Same as above but for floor (4) to floor (5) level.		5.00	Cum	626.34	3131.70
(d)	Same as above but for floor (5) to floor (6) level.		5.00	Cum	632.42	3162.10
(e)	Same as above but for floor (6) to floor (7) level.		5.00	Cum	638.51	3192.55
(f)	Same as above but for floor (7) to floor (8) level.		5.00	Cum	644.59	3222.95
(g)	Same as above but for floor (8) to floor (9) level.		5.00	Cum	650.67	3253.35
(h)	Same as above but for floor (9) to floor (10) level.		5.00	Cum	656.75	3283.75
(i)	Same as above but for floor (10) to floor (11) level.		5.00	Cum	662.83	3314.15
(j)	Same as above but for floor (11) to floor (12) level.		5.00	Cum	668.91	3344.55
(k)	Same as above but for floor (12) to floor (13) level.		5.00	Cum	674.99	3374.95
(l)	Same as above but for floor (13) to floor (14) level.		5.00	Cum	681.07	3405.35
(m)	Same as above but for floor (14) to floor (15) level.		5.00	Cum	687.15	3435.75
(n)	Same as above but for floor (15) to floor (16) level.		5.00	Cum	693.23	3466.15

1.	2.	3.	4.	5.	6.	7.
(o)	Same as above but for floor (16) to floor (17) level.		1.00	Cum	699.32	699.32
(p)	Same as above but for floor (17) to floor (18) level.		1.00	Cum	705.40	705.40
3.6	Reinforced cement concrete work in litels, beams, plinths, beams and bressummers upto floor two level excluding the cost of centring, shuttering, finishing and reinforcement with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	5.6/ p.97	139.00	Cum	577.60	80286.40
(a)	Same as above but for floor (2) to floor (3) level.		70.00	Cum	583.38	40836.60
(b)	Same as above but for floor (3) to floor (4) level		70.00	Cum	589.15	41240.50
(c)	Same as above but for floor (4) to floor (5) level.		70.00	Cum	594.93	41465.10
(d)	Same as above but for floor (5) to floor (6) level.		70.00	Cum	600.70	42049.00
(e)	Same as above but for floor (6) to floor (7) level.		70.00	Cum	606.48	42453.60
(f)	Same as above but for floor (7) to floor (8) level.		70.00	Cum	612.26	42858.20
(g)	Same as above but for floor (8) to floor (9) level.		70.00	Cum	618.03	43262.10

1.	2.	3.	4.	5.	6.	7.
(h)	Same as above but for floor (9) to floor (10) level.		70.00	Cum	623.81	43666.70
(i)	Same as above but for floor (10) to floor (11) level.		70.00	Cum	629.58	44070.60
(j)	Same as above but for floor (11) to floor (12) level.		70.00	Cum	635.36	44475.20
(k)	Same as above but for floor (12) to floor (13) level.		70.00	Cum	641.14	44879.80
(l)	Same as above but for floor (13) to floor (14) level.		70.00	Cum	646.91	45283.70
(m)	Same as above but for floor (14) to fllor (15) level.		70.00	Cum	652.69	45688.30
(n)	Same as above but for floor (15) to floor (16) level.		70.00	Cum	658.46	46092.20
(o)	Same as above but for floor (16) to floor (17) level.		26.00	Cum	664.24	17270.24
(p)	Same as above but for floor (17) to floor (18) level.		22.00	Cum	670.02	14740.44
3.7	Reinforced cement concrete work in columns, pillars, piers, abutments posts and struts upto floor two level excluding the cost of centring, shuttering, finishing and reinforcement 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate of nominal size 20 mm)	5.7/ p.97	170.00	Cum	593.70	100929.00

1.	2.	3.	4.	5.	6.	7.
(a)	Same as above but for floor (2) to floor (3) level.		80.00	Cum	599.64	47971.20
(b)	Same as above but for floor (3) to floor (4) level.		80.00	Cum	605.57	48445.60
(c)	Same as above but for floor (4) to floor (5) level.		80.00	Cum	611.51	48920.80
(d)	Same as above but for floor (5) to floor (6) level.		80.00	Cum	617.45	49396.00
(e)	Same as above but for floor (6) to floor (7) level.		80.00	Cum	623.39	49871.20
(f)	Same as above but for floor (7) to floor (8) level.		80.00	Cum	629.32	50345.60
(g)	Same as above but for floor (8) to floor (9) level.		80.00	Cum	635.26	50820.80
(h)	Same as above but for floor (9) to floor (10) level.		80.00	Cum	641.20	51296.00
(i)	Same as above but for floor (10) to floor (11) level.		80.00	Cum	647.13	51770.40
(j)	Same as above but for floor (11) to floor (12) level.		80.00	Cum	653.07	52245.60
(k)	Same as above but for floor (12) to floor (13) level.		80.00	Cum	659.01	52720.80
(l)	Same as above but for floor (13) to floor (14) level.		80.00	Cum	664.94	53195.20
(m)	Same as above but for floor (14) to floor (15) level.		80.00	Cum	670.88	53670.40

1.	2.	3.	4.	5.	6.	7.
(n)	Same as above but for floor (15) to floor (16) level.		80.00	Cum	676.82	54145.60
(o)	Same as above but for floor (16) to floor (17) level.		11.00	Cum	682.75	7510.25
(p)	Same as above but for floor (17) to floor (18) level.		6.00	Cum	688.69	4132.14
3.8	Reinforced cement concrete work in staircase (excluding landings) except spiral stair-cases preparing of the top surface and finishing, nosing upto floor two level but excluding the cost of centring, shuttering, finishing and reinforcement with 1:2:4. (1 cement : 2 Coarse sand : graded stone aggregate 20 mm nominal size).	5.8/ p.98	5.00	Cum	620.75	3103.75
(a)	Same as above but for floor (2) to floor (3) level.		2.00	Cum	626.96	1253.92
(b)	Same as above but for floor (3) to floor (4) level.		2.00	Cum	633.17	1266.34
(c)	Same as above but for floor (4) to floor (5) level.		2.00	Cum	639.37	1278.74
(d)	Same as above but for floor (5) to floor (6) level.		2.00	Cum	645.58	1291.16
(e)	Same as above but for floor (6) to floor (7) level.		2.00	Cum	651.79	1303.58
(f)	Same as above but for floor (7) to floor (8) level.		2.00	Cum	658.00	1316.00

1.	2.	3.	4.	5.	6.	7.
(g)	Same as above but for floor (8) to floor (9) level.		2.00	Cum	664.20	1328.40
(h)	Same as above but for floor (9) to floor (10) level.		2.00	Cum	670.41	1340.82
(i)	Same as above but for floor (10) to floor (11) level.		2.00	Cum	676.62	1353.24
(j)	Same as above but for floor (11) to floor (12) level.		2.00	Cum	682.83	1365.66
(k)	Same as above but for floor (12) to floor (13) level.		2.00	Cum	689.03	1378.06
(l)	Same as above but for floor (13) to floor (14) level.		2.00	Cum	695.24	1390.48
(m)	Same as above but for floor (14) to floor (15) level.		2.00	Cum	701.45	1402.90
(n)	Same as above but for floor (15) to floor (16) level.		2.00	Cum	707.66	1415.32
3.9	Reinforce cement concrete work in vertical and horizontal fins individually or forming box louvers and facias upto floor two level excluding the cost of centring, shuttering, finishing and reinforcement with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 mm nominal size).	5.13/ p.99	3.00	Cum	607.25	1821.75
(a)	Same as above but for floor (2) to floor (3) level.		3.00	Cum	613.22	1839.96

1.	2.	3.	4.	5.	6.	7.
(b)	Same as above but for floor (3) to floor (4) level.		3.00	Cum	619.40	1858.20
(c)	Same as above but for floor (4) to floor (5) level.		3.00	Cum	625.47	1876.41
(d)	Same as above but for floor (5) to floor (6) level.		3.00	Cum	631.54	1894.62
(e)	Same as above but for floor (6) to floor (7) level.		3.00	Cum	637.61	1912.83
(f)	Same as above but for floor (7) to floor (8) level.		3.00	Cum	643.69	1931.07
(g)	Same as above but for floor (8) to floor (9) level.		3.00	Cum	649.76	1949.28
(h)	Same as above but for floor (9) to floor (10) level.		3.00	Cum	655.83	1967.49
(i)	Same as above but for floor (10) to floor (11) level.		3.00	Cum	661.93	1985.79
(j)	Same as above but for floor (11) to floor (12) level.		3.00	Cum	667.98	2003.94
(k)	Same as above but for floor (12) to floor (13) level.		3.00	Cum	674.05	2022.15
(l)	Same as above but for floor (13) to floor (14) level.		3.00	Cum	680.12	2040.36
(m)	Same as above but for floor (14) to floor (15) level.		3.00	Cum	686.19	2058.57
(n)	Same as above but for floor (15) to floor (16) level.		3.00	Cum	692.27	2076.81

1.	2.	3.	4.	5.	6.	7.
(o)	Same as above but for floor (16) to floor (17) level.		3.00	Cum	698.34	2095.02
(p)	Same as above but for floor (17) to floor (18) level.		3.00	Cum	704.41	2113.23
3.10	Providing and laying upto floor two level R.C.C. in string courses bands, copings, bed plates, anchor blocks plain window sills and the like excluding the cost of centring, shuttering, finishing & reinforcement with 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size).	5.16/ p.100	1.00	Cum	588.15	588.15
(a)	Same as above but for floor (2) to floor (3) level.		1.00	Cum	594.03	594.03
(b)	Same as above but for floor (3) to floor (4) level.		1.00	Cum	599.91	599.91
(c)	Same as above but for floor (4) to floor (5) level.		1,00	Cum	605.79	605.79
(d)	Same as above but for floor (5) to floor (6) level.		1.00	Cum	611.68	611.68
(e)	Same as above but for floor (6) to floor (7) level.		1.00	Cum	617.56	617.56
(f)	Same as above but for floor (7) to floor (8) level.		1.00	Cum	623.44	623.44
(g)	Same as above but for floor (8) to floor (9) level.		1.00	Cum	629.32	629.32
(h)	Same as above but for floor (9) to floor (10) level.		1.00	Cum	635.20	635.20

					641.08	641.08
(i)	Same as above to floor (11) level					
(j)	Same as above but for floor (11) to floor (12) level.		1.00	Cum	646.97	646.97
(k)	Same as above but for floor (12) to floor (13) level.		1.00	Cum	652.85	652.85
(l)	Same as above but for floor (13) to floor (14) level.		1.00	Cum	658.73	658.73
(m)	Same as above but for floor (14) to floor (15) level.		1.00	Cum	664.61	664.61
(n)	Same as above but for floor (15) to floor (16) level.		1.00	Cum	670.49	670.49
(o)	Same as above but for floor (16) to floor (17) level.		0.50	Cum	676.37	338.19
(p)	Same as above but for floor (17) to floor (18) level.		0.50	Cum	682.25	341.12
3.11	Providing precase cement concrete jali 1:2:4 (1 cement : 2 coarse sand : 4 stone aggregate 6 mm nominal size) reinforced with 1.6 mm dia. Mild steel wire including roughening, cleaning, fixing and finishing in cement mortar 1:3 (1 cement : 3 fine sand etc. complete excluding plastering of jambs, sills and soffits - 40 mm thick (of approved design/pattern) for all floors).	5.25/ p.102	200.00	sqm	76.30	15260.00

1.	2.	3.	4.	5.	6.	7.
3.12	Reinforcement for R.C.C. work including bending, binding and placing in position complete.	5.29/ p.103				
(a)	Mild Steel and medium tensile steel bars		10000	kg	8.85	88500.00
(b)	Cold twisted bars		1000000	kg	9.10	9100000.00
3.13	Extra for using (1:1.5:3) concrete mix for all R.C. works instead of 1;2:4.	5.7/	700.00	Cum	75.20	52640.00
3.14	Extra for using (1:2:2) concrete mix for all RCC works instead of 1:2:4.	5.7/ 0.97	400.00	Cum	291.65	116660.00
3.15	Centring and shuttering including strutting, propping etc. and removal of form for :	5.14/ 0.99				
(a)	Foundations, footings bases, of coloumns etc. mass concrete and precast shelves.		265.00	sqm	22.65	6002.25
(b)	Walls (any thickness) including attached plasters, butteress, plinth and string courses etc.		1910.00	sqm	31.25	59687.50
(c)	Suspended floor, roofs, landings and balconies.		13660.00	sqm	47.80	652948.00
(d)	Shelves		200.00	sqm	47.80	9860.00
(e)	Lintels, beams, plinth beams girders, bressummers and cantilevers.		9400.00	sqm	29.25	274950.00

1.	2.	3.	4.	5.	6.	7.
(f)	Columns, pillars, posts and struts.		12260.00	sqm	38.55	472623.00
(g)	Staircase (exclduing landings) except spiral stair case (including landing)		240.00	sqm	31.70	7608.00
(h)	Extra for shuttering in circular works (20% of respective works)		1310.00	sqm	7.71	10100.10
(i)	Horizontal and vertical fins individually or forming box louvors band and facias.		320.00	sqm	44.45	14224.00
4.	**BRICK WORK**					
4.1	Brick work with bricks of class designation 75 in foundation and plinth in cement mortar 1:6 (1 cement : 6 coarse sand).	6.1/ p.106	20.00	Cum	391.45	7829.00
4.2	Brick work with bricks of class designation 75 in superstructure above plinth (floor one level) upto floor two level in cement mortar (1:6) (1 cement : 6 coarse sand).	6.1+ 6.3/ p.106	175.00	Cum	408.55	71496.25
(a)	Same as above but for floor (2) to floor (3) level.		155.00	Cum	412.64	63959.20
(b)	Same as above but for floor (3) to floor (4) level.		155.00	Cum	416.72	64591.60
(c)	Same as above but for floor (4) to floor (5) level.		155.00	Cum	420.81	65225.55
(d)	Same as above but for floor (5) to floor (6) level.		155.00	Cum	424.89	65857.95

1.	2.	3.	4.	5.	6.	7.
(e)	Same as above but for floor (6) to floor (7) level.		155.00	Cum	428.98	66491.90
(f)	Same as above but for floor (7) to floor (8) level.		155.00	Cum	433.06	67124.30
(g)	Same as above but for floor (8) to floor (9) level.		155.00	Cum	437.15	67758.25
(h)	Same as above but for floor (9) to floor (10) level.		155.00	Cum	441.23	68390.65
(i)	Same as above but for floor (10) to floor (11) level.		155.00	Cum	445.12	68993.60
(j)	Same as above but for floor (11) to floor (12) level.		155.00	Cum	449.41	69658.55
(k)	Same as above but for floor (12) to floor (13) level.		155.00	Cum	453.49	70290.95
(l)	Same as above but for floor (13) to floor (14) level.		155.00	Cum	457.58	70924.90
(m)	Same as above but for floor (14) to floor (15) level.		155.00	Cum	461.66	71557.30
(n)	Same as above but for floor (15) to floor (16) level.		155.00	Cum	465.75	72191.25
(o)	Same as above but for floor (16) to floor (17) level.		68.00	cum	469.83	31948.44
(p)	Same as above but for floor (17) to floor (18) level.		10.00	Cum	473.92	4739.20

1.	2.	3.	4.	5.	6.	7.
4.3	Extra for brick work curved on plan upto a mean radius not exceeding 6 mts.	MR	60.00	Cum	57.00	3420.00
4.4	Half brick masonry with bricks of class designation 75 in foundation and plinth : in cement mortar 1:4 (1 cement : 4 coarse sand).	6.18/ p.108	530.00	sqm	52.20	27666.00
4.5	Half brick masonry with bricks of class designation 75 in super-structure from plinth (floor one level) to floor two level in cement mortar 1:4 (1 cement : 4 coarse sand).	6.18+ 6.19/ p.108	360.00	sqm	55.30	19908.00
(a)	Same as above but for floor (2) to floor (3) level.		400.00	sqm	55.85	22340.00
(b)	Same as above but for floor (3) to floor (4) level.		400.00	sqm	56.41	22564.00
(c)	Same as above but for floor (4) to floor (5) level.		400.00	sqm	56.96	22784.00
(d)	Same as above but for floor (5) to floor (6) level.		400.00	sqm	57.51	23004.00
(e)	Same as above but for floor (6) to floor (7) level.		400.00	sqm	58.07	23228.00
(f)	Same as above but for floor (7) to floor (8) level.		400.00	sqm	58.62	23448.00
(g)	Same as above but for floor (8) to floor (9) level.		400.00	sqm	59.17	23668.00

1.	2.	3.	4.	5.	6.	7.
(h)	Same as above but for floor (9) to floor (10) level.		400.00	sqm	59.72	23888.00
(i)	Same as above but for floor (10) to floor (11) level.		400.00	sqm	60.28	24112.00
(j)	Same as above but for floor (11) to floor (12) level.		400.00	sqm	60.83	24332.00
(k)	Same as above but for floor (12) to floor (13) level.		400.00	sqm	61.38	24552.00
(l)	Same as above but for floor (13) to floor (14) level.		400.00	sqm	61.94	24776.00
(m)	Same as above but for floor (14) to floor (15) level.		400.00	sqm	62.49	24996.00
(n)	Same as above but for floor (15) to floor (16) level.		400.00	sqm	63.04	25216.00
(o)	Same as above but for floor (16) to floor (17) level.		150.00	sqm	63.60	9540.00
(p)	Same as above but for floor (17) to floor (18) level.		10.00	sqm	64.15	641.50
4.6	Extra for making tapered surface of brick masonary for steps.	M/R	250.00	Cum	25.00	6250.00
5.	**WOOD WORK**					
5.1	Providing fixing flush door shutters non-decorative type, core of block board construction with frame of Ist class hard wood and well matched commercial ply veneering with verical grains or	9.25/ p.134	1700.00	sqm	425.15	722755.00

1.	2.	3.	4.	5.	6.	7.
	cross bands and face venners on both faces of shutters. 35 mm thick including anodised aluminium butt hinges with necessary screws.					
5.2	Extra for providing lipping with Ist class teak wood battens 25mm minimum depth on all edges of shutters (overall area of door shutter to be measured).	9.34/ p.138	1700.00	sqm	57.75	98175.00
5.3	Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats square or round bars with round headed bolts and nuts or by screws or welding,	9.82 p.146	8300.00	kg	12.45	103335.00
5.4	Providing and fixing aluminium sliding door bolts anodised transparent or dyed to required colour or shade with nuts and screws etc. complete.	9.218/ p.146				
(a)	300x16 mm		450.00	each	42.80	19260.00
(b)	250x16 mm		450.00	each	41.60	18720.00
5.5	Providing and fixing aluminium tower bolts anodised transparent or dyed to required colour or shade with necessary screws etc complete.	9.219/ p.163				
(a)	250x10 mm		2460.00	each	11.95	29397.00
(b)	200x10 mm		2460.00	each	10.75	26445.00

1.	2.	3.	4.	5.	6.	7.
5.6	Providing and fixing aluminium handles anodised transparent or dyed to required colour or shade with necessary screws etc. complete - 100 mm	9.222/ p.164	3450.00	each	14.35	49507.50
5.7	Providing and fixing aluminium hanging floor door stopper anodised transparent or dyed to require colour and shadewith necessary screws at etc. complete.	9.223/ p.164	900.00	each	5.15	4635.00
6.	**STEEL WORK**					
6.1	Providing and fixing steel glazed doors windows and ventilators of standard rolled steel sections, joints mitred and welded with 15x3 mm lugs, 10 cm long, with steel lugs, embedded in cement concrete blocks 15x10x10 cm of 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size) or with wooden plugs and screws or rawl plugs and screws or with fixing clips or with bolts and nuts as required, including providing and fixing of 4 mm thick glass panes with glazzing clips and special metal sash putty of approved make complete including applying a priming coat of approved steel primer; excluding the cost of metal beading and other fitting except necessary hinges or pivots as required.	10.12/ p.167				

1.	2.	3.	4.	5.	6.	7.
(a)	Doors		540.00	sqm	546.20	294948.00
(b)	Windows fixed		360.00	sqm	311.75	112230.00
(c)	Windows-side hung		720.00	sqm	409.50	294840.00
(d)	Ventilators-top hung		180.00	sqm	409.50	73710.50
6.2	Providing and fixing pressed steel door frames manufactured from commercial mild steel sheet of 1.25 mm thickness including hinges jamb, rawl plugs, lock jamb, bead and if required angle treshhold of mold steel angle of section 50x25 mm or base ties of 1.25 mm pressed mild steel welded or rigidly fixed toegether by mechanical means, adjustable lugs, with split and tail to each jamb including steel butt hinges 2.5 mm thick with mortar guards lock strike plate and shock absorbers as specified and applying a coat of approved steel primer after pre-treatment of the surface as directed by Engineer Incharge. Profile A.	10.15/ p.168	4650.00	mtrs	59.15	275027.50
6.3	Providing and fixing bright finsihed brass casement window fasteners of minimum weight 200 grams to side-hung steel windows with necessary welding and machine screws etc. complete.	10.28/ p.169	1650.00	each	15.40	25410.00

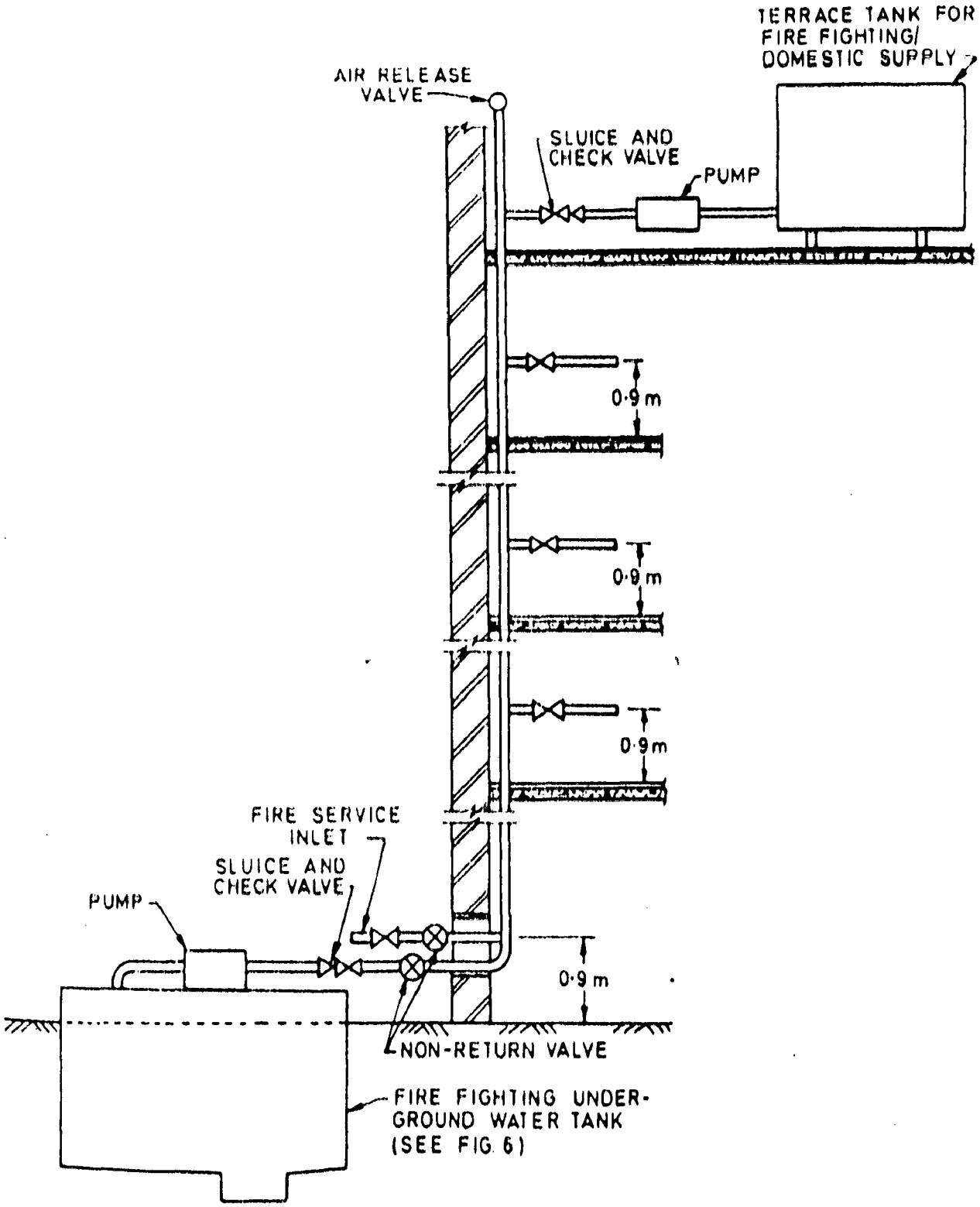


Fig. 2 Typical Arrangement of Wet Riser-cum-Downcomer for Apartment Houses Exceeding 24 m in Height

1.	2.	3.	4.	5.	6.	7.
4.3	Extra for brick work curved on plan upto a mean radius not exceeding 6 mts.	MR	60.00	Cum	57.00	3420.00
4.4	Half brick masonry with bricks of class designation 75 in foundation and plinth : in cement mortar 1:4 (1 cement : 4 coarse sand).	6.18/ p.108	530.00	sqm	52.20	27666.00
4.5	Half brick masonry with bricks of class designation 75 in super-structure from plinth (floor one level) to floor two level in cement mortar 1:4 (1 cement : 4 coarse sand).	6.18+ 6.19/ p.108	360.00	sqm	55.30	19908.00
(a)	Same as above but for floor (2) to floor (3) level.		400.00	sqm	55.85	22340.00
(b)	Same as above but for floor (3) to floor (4) level.		400.00	sqm	56.41	22564.00
(c)	Same as above but for floor (4) to floor (5) level.		400.00	sqm	56.96	22784.00
(d)	Same as above but for floor (5) to floor (6) level.		400.00	sqm	57.51	23004.00
(e)	Same as above but for floor (6) to floor (7) level.		400.00	sqm	58.07	23228.00
(f)	Same as above but for floor (7) to floor (8) level.		400.00	sqm	58.62	23448.00
(g)	Same as above but for floor (8) to floor (9) level.		400.00	sqm	59.17	23668.00

1.	2.	3.	4.	5.	6.	7.
(h)	Same as above but for floor (9) to floor (10) level.		400.00	sqm	59.72	23888.00
(i)	Same as above but for floor (10) to floor (11) level.		400.00	sqm	60.28	24112.00
(j)	Same as above but for floor (11) to floor (12) level.		400.00	sqm	60.83	24332.00
(k)	Same as above but for floor (12) to floor (13) level.		400.00	sqm	61.38	24552.00
(l)	Same as above but for floor (13) to floor (14) level.		400.00	sqm	61.94	24776.00
(m)	Same as above but for floor (14) to floor (15) level.		400.00	sqm	62.49	24996.00
(n)	Same as above but for floor (15) to floor (16) level.		400.00	sqm	63.04	25216.00
(o)	Same as above but for floor (16) to floor (17) level.		150.00	sqm	63.60	9540.00
(p)	Same as above but for floor (17) to floor (18) level.		10.00	sqm	64.15	641.50
4.6	Extra for making tapered surface of brick masonary for steps.	M/R	250.00	Cum	25.00	6250.00
5.	**WOOD WORK**					
5.1	Providing fixing flush door shutters non-decorative type, core of block board construction with frame of Ist class hard wood and well matched commercial ply veneering with verical grains or	9.25/ p.134	1700.00	sqm	425.15	722755.00

1.	2.	3.	4.	5.	6.	7.
	cross bands and face venners on both faces of shutters. 35 mm thick including anodised aluminium butt hinges with necessary screws.					
5.2	Extra for providing lipping with Ist class teak wood battens 25mm minimum depth on all edges of shutters (overall area of door shutter to be measured).	9.34/ p.138	1700.00	sqm	57.75	98175.00
5.3	Providing and fixing M.S. grills of required pattern in frames of windows etc. with M.S. flats square or round bars with round headed bolts and nuts or by screws or welding,	9.82 p.146	8300.00	kg	12.45	103335.00
5.4	Providing and fixing aluminium sliding door bolts anodised transparent or dyed to required colour or shade with nuts and screws etc. complete.	9.218/ p.146				
(a)	300x16 mm		450.00	each	42.80	19260.00
(b)	250x16 mm		450.00	each	41.60	18720.00
5.5	Providing and fixing aluminium tower bolts anodised transparent or dyed to required colour or shade with necessary screws etc complete.	9.219/ p.163				
(a)	250x10 mm		2460.00	each	11.95	29397.00
(b)	200x10 mm		2460.00	each	10.75	26445.00

1.	2.	3.	4.	5.	6.	7.
5.6	Providing and fixing aluminium handles anodised transparent or dyed to required colour or shade with necessary screws etc. complete - 100 mm	9.222/ p.164	3450.00	each	14.35	49507.50
5.7	Providing and fixing aluminium hanging floor door stopper anodised transparent or dyed to require colour and shadewith necessary screws at etc. complete.	9.223/ p.164	900.00	each	5.15	4635.00
6.	**STEEL WORK**					
6.1	Providing and fixing steel glazed doors windows and ventilators of standard rolled steel sections, joints mitred and welded with 15x3 mm lugs, 10 cm long, with steel lugs, embedded in cement concrete blocks 15x10x10 cm of 1:3:6 (1 cement : 3 coarse sand : 6 graded stone aggregate 20 mm nominal size) or with wooden plugs and screws or rawl plugs and screws or with fixing clips or with bolts and nuts as required, including providing and fixing of 4 mm thick glass panes with glazzing clips and special metal sash putty of approved make complete including applying a priming coat of approved steel primer; excluding the cost of metal beading and other fitting except necessary hinges or pivots as required.	10.12/ p.167				

1.	2.	3.	4.	5.	6.	7.
(a)	Doors		540.00	sqm	546.20	294948.00
(b)	Windows fixed		360.00	sqm	311.75	112230.00
(c)	Windows-side hung		720.00	sqm	409.50	294840.00
(d)	Ventilators-top hung		180.00	sqm	409.50	73710.50
6.2	Providing and fixing pressed steel door frames manufactured from commercial mild steel sheet of 1.25 mm thickness including hinges jamb, rawl plugs, lock jamb, bead and if required angle treshhold of mold steel angle of section 50x25 mm or base ties of 1.25 mm pressed mild steel welded or rigidly fixed toegether by mechanical means, adjustable lugs, with split and tail to each jamb including steel butt hinges 2.5 mm thick with mortar guards lock strike plate and shock absorbers as specified and applying a coat of approved steel primer after pre-treatment of the surface as directed by Engineer Incharge. Profile A.	10.15/ p.168	4650.00	mtrs	59.15	275027.50
6.3	Providing and fixing bright finsihed brass casement window fasteners of minimum weight 200 grams to side-hung steel windows with necessary welding and machine screws etc. complete.	10.28/ p.169	1650.00	each	15.40	25410.00

1.	2.	3.	4.	5.	6.	7.
6.4	Providing and fixing bright finished brass peg stays 300 mm long (of minimum weight 330 gms) to side hung steel windows with necessary welding and machine screws etc. complete.	10.29/ p.169	1650.00	Nos.	28.85	47602.50
6.5	Providing a fixing bright finish brass 100 mm mortice latch and lock of approve make with 6 levers and a pair of anodised aluminium lever handles with necessary screws etc. complete.	9.225/ p.164	120.00	Nos.	145.15	17418.00
6.6	Providing and fixing 1 mm thick m.s. sheet door shutter with frame and diagonal braces of 40x40x6 mm angle iron and 3 mm thick M.S. gusset plates at the junction and corners, all necessary fittings complete including applying a coat of primer.	10.7/	10.00	sqm	400.35	4003.50

APPENDIX - 2

ABSTRACT OF COST FOR ANUPAM CGHS (A&B)

1. Common Facilities :

(i)	Lifts	Rs. 70,00,000.00
(ii)	Firefighting	Rs. 17,00,000.00
(iii)	External Water Line/ Sewerage work	Rs. 10,00,000.00
(iv)	Tubewell & Booster pump	Rs. 2,50,000.00
(v)	Diesel Generator	Rs. 3,50,000.00
(vi)	Open drains/roadwork	Rs. 9,00,000.00
(vii)	Architect fee	Rs. 4,25,000.00
(viii)	Soceity overheads	Rs. 6,00,000.00
(ix)	D.E.S.U. Deposit	Rs. 16,00,000.00
		Rs.138,25,000.00
	Total number of flats	100
	Per memebr cost	Rs. 1,38,250.00

Sl. No.	Description	Type A	Type B	Total Cost
1.	Common facilities	1,38,250/-	1,38,250/-	138,25,000/-
2.	Civil work	4,21,335/-	3,19,610/-	369,97,250/-
3.	Wiring cost	38,200/-	30,000/-	34,10,000/-
4.	Internal water supply	35,000/-	28,000/-	31,60,000/-
5.	Garbage chute/ sintex tank/ water proofing	10,305/-	7,735/-	9,02,000/-

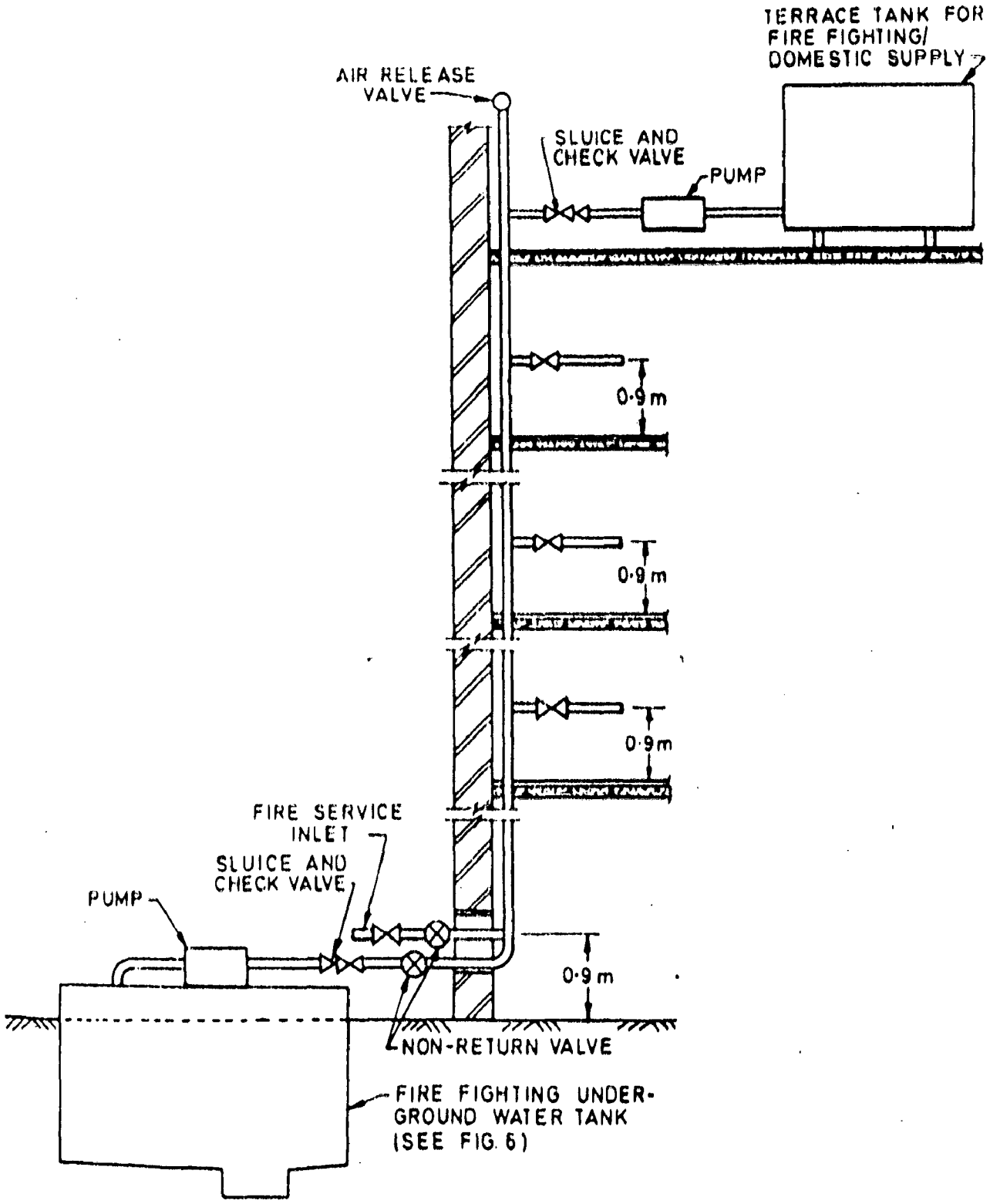


Fig. 2 Typical Arrangement of Wet Riser-cum-Downcomer for Apartment Houses Exceeding 24 m in Height

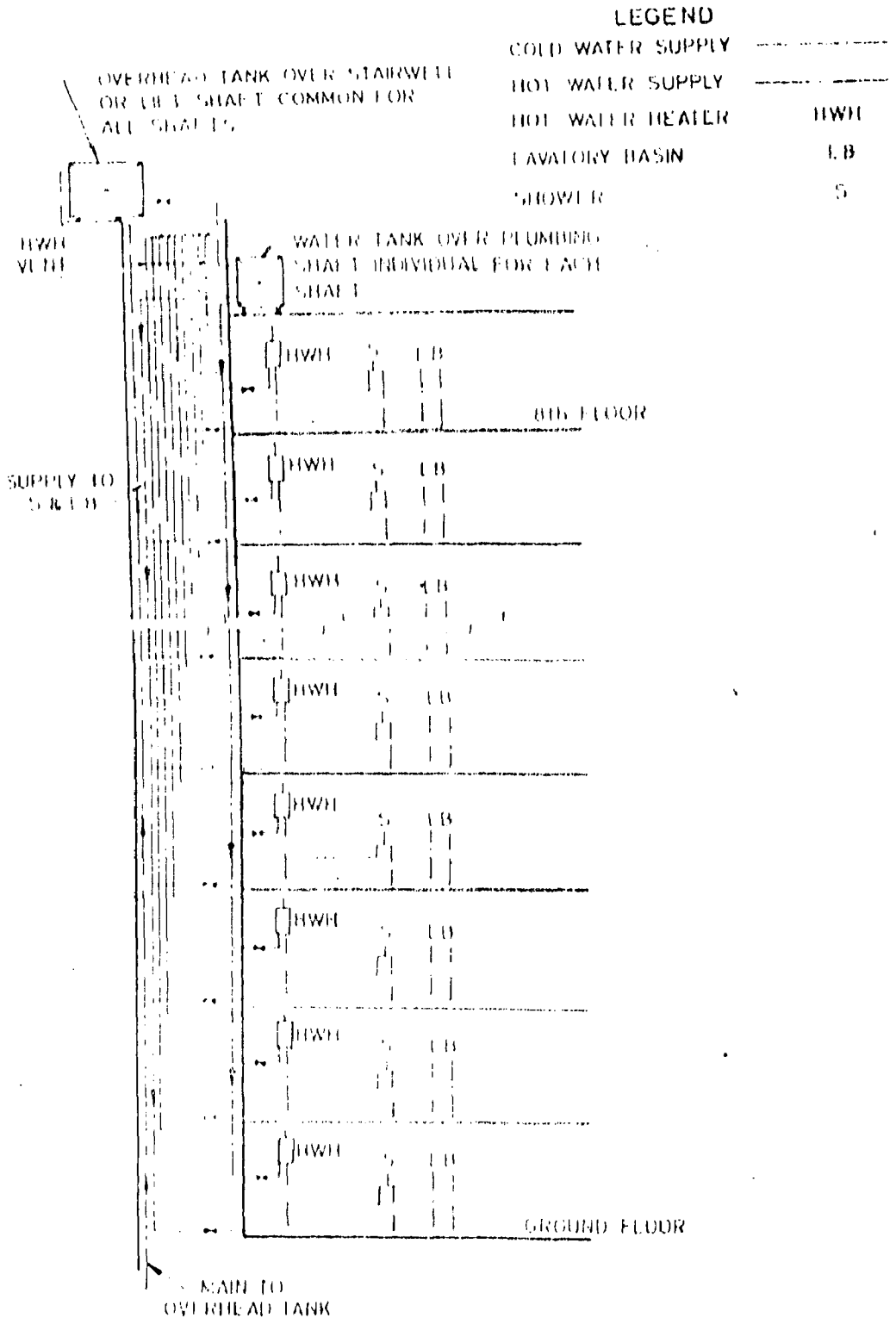


Fig 2 Installation for 8 Storeyed Building

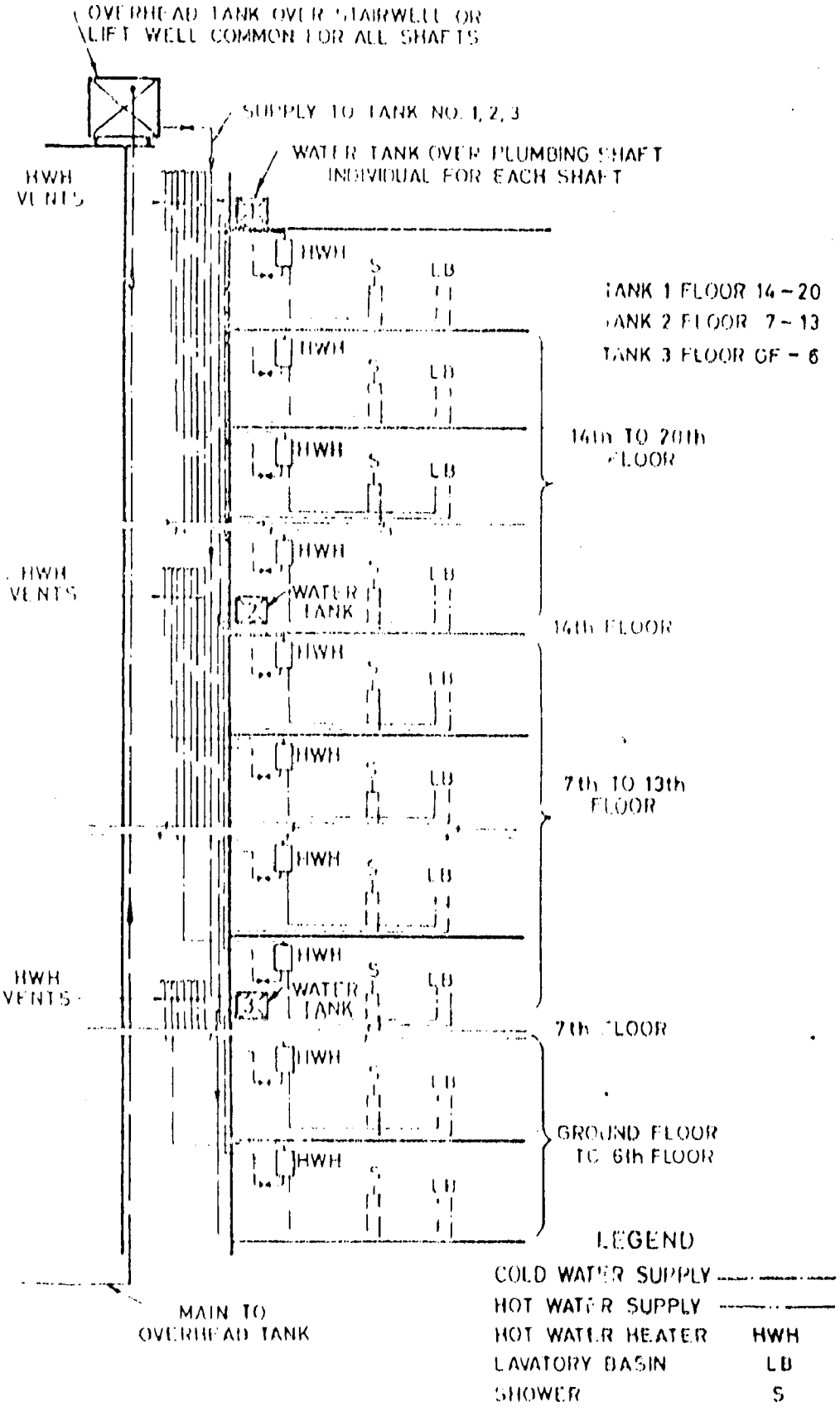


Fig. 3 Installation for 20 Storied Building

Number of Connections of Various Sizes that can be Fed from a Main Line that will together have the same discharge as the main line

Dia. of Delivery Main	Diameter of Branch Pipe in mm														
	15	20	25	32	40	50	65	80	100	125	150	200	250	300	350
	Number of Branch Connections														
15	1														
20	3	1													
25	6	2	1												
32	10	3	1.7	1											
40	16	6	2.7	1.6	1										
50	32	12	5.6	3.2	2	1									
65	56	20	10	5.6	3.6	1.7	1								
80	88	32	16	8.9	5.6	2.7	1.6	1							
100	181	66	32	18	11	5.6	3.2	2	1						
125		115	56	32	20	10	5.6	3.6	1.7	1					
150		181	88	50	32	15	8.9	5.6	2.7	1.6	1				
200			181		66	32	18	11	5.6	3.2	2	1			
250			316		115	56	32	20	10	5.6	3.6	1.7	1		
300						88	50	32	16	8.9	5.6	2.7	1.6	1	
350						130	74	47	23	13	8.3	4.0	2.3	1.5	1
400								66	32	18	11	5.6	3.2	2.0	1.4
450								88	43	25	16	7.6	4.3	2.7	1.9
500								115	56	32	20	10	5.6	3.6	2.4
600									88	50	32	16	8.9	5.6	3.8
700										74	47	23	13	8.3	5.6
750										88	56	27	16	10	6.5

Dia. of Delivery Main	Diameter of Branch Pipe in mm														
	200	250	300	350	400	450	500	600	700	750	800	900	1000	1100	1200	1500
mm	Number of Branch Connections															
400					1											
450					1.3	1										
500					1.7	1.3	1									
600					2.7	2.0	1.6	1								
700					4.0	3.0	2.3	1.5	1							
750					4.8	3.6	2.7	1.7	1.2	1						
800	32	18	11	7.9	5.6	4.2	3.2	2.0	1.4	1.2	1					
900	43	25	16	8.5	7.6	5.6	4.3	2.7	1.9	1.6	1.3	1				
1000	56	32	20		10	7.3	5.6	3.6	2.4	2.0	1.7	1.3	1			
1100	71	41	26			9.3	7.2	4.5	3.1	2.6	2.2	1.6	1.3	1		
1200	88	50	32				8.9	5.6	3.8	3.2	2.7	2.0	1.6	1.2	1	
1500	143	88	56				15	10	6.5	5.6	4.8	3.6	2.7	2.2	1.7	1

To know what number of pipes of a given size are equal in carrying capacity to one pipe of a larger size: At the same velocity of flow the volume delivered by two pipes of different sizes is proportional to the square of their diameters. Thus, one 100-mm dia. pipe will deliver the same volume as four 50-mm pipes. With the same head, however, the velocity is less in the smaller pipe, and the volume delivered varies about as the square root of the 5th power (*i.e.*, discharge varies as $\sqrt{\text{dia.}^5}$. The table has been calculated on this basis. The figures opposite the intersection of any two sizes represent the number of the smaller-sized pipes required to equal one of the larger. Thus, one 100-mm pipe is equal to 5.6 50 mm pipes.

$$\text{Number required} = \sqrt{\left(\frac{\text{Dia. of larger pipe}}{\text{Dia. of smaller pipe}}\right)^5}$$

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