



**GOVERNMENT OF INDIA
MINISTRY OF WORKS & HOUSING**

**REPORT
OF THE
TECHNICAL COMMITTEE ON ECONOMY
IN THE USE OF CEMENT AND STEEL
IN
BUILDING CONSTRUCTION**

NOVEMBER, 1974

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PREFACE

0.1 The country has been facing shortage of essential construction materials like cement and steel for the past few years and the position has been gradually deteriorating. In a meeting held under the aegis of the Planning Commission in May, 1974, it was decided that a Technical Committee be set up by the Ministry of Works & Housing to go into the matter and suggest measures that should be adopted for bringing about economy in the use of essential construction materials like cement and steel in building industry. In pursuance to that decision, a Technical Committee was set up by the Ministry of Works & Housing vide their No. N-16012/1/73-PS dated 8-7-1974. Some more members were added to this Committee by the Ministry of Works & Housing vide their No. N-16012/1/73-PS dated 24-8-1974. Copies of these orders are enclosed as Appendices A1 and A2.

0.2 Terms of reference of this Committee were as follows :

- (i) To study and recommend changes required in architectural concept, structural designs and space standards for ordinary buildings to allow for greater use of local materials like lime, surkhi, stone, tiles, timber etc. to ensure economy in the use of cement and steel and measures for getting these changes accepted and implemented ;
- (ii) To recommend operational measures which would allow for immediate use of fly ash in Civil works of PWDs, Public Sector Undertakings and other Government Works ;
- (iii) To recommend amendments to PWD and departmental specifications, rules and procedures to

(iii)

(iv)

allow for greater use of local materials referred to in (i) above ;

- (iv) To examine and suggest measures for implementation of the recommendations of the Committee on economy in consumption of steel in the country in so far as they concern building construction ;
- (v) To study the technical feasibility and suggest use of precast building components like channel units, cored units, battens and hollow blocks and cellular units, with a view to reducing consumption of cement and steel *vis-a-vis* conventional RCC construction ;
- (vi) To recommend amendments to National Building Code so as to include provisions for greater use of local materials and simplification of the relevant parts of the Code to facilitate their adoption by local authorities.

0.3 The Committee held meetings in New Delhi on 30th and 31st August, 26th, 27th, 28th September and 11th November, 1974. The Committee was required to submit an interim report within three months and final report within six months. In view of the urgency and importance of the matter, however, the Committee thought it proper to send the final report itself within a period of about four months so that measures for effecting economy in the use of cement and steel could be brought into force with the least possible delay.

0.4 The Committee, during its deliberations, reviewed the recommendations contained in the Reports of some earlier committees which had some bearing on the subject matter of this Committee and has in its Report referred to some of the recommendations of the earlier Committees.

0.5 Recommendations contained in this Report apply only to ordinary buildings like residences, offices, schools, dispensaries etc. and do not apply to industrial complexes, hospitals and other buildings having special requirements.

(v)

0.6 Since, apart from other factors, cost of building materials depends on relation between demand and supply, it is likely that construction of buildings based on greater use of local materials which are not at present being manufactured/produced in the country in sufficient quantity may cost more in the initial stages. It is, however, expected that with the gradual stepping up of production/manufacture of these materials, and improvement in quality, cost of construction will come down.

0.7 In Section 3 of the Report the Committee has recommended adoption of certain alternative specifications based on the use of materials like lime, surkhi, stone slabs, roofing tiles etc. in the context of present shortage in cement and steel. Buildings based on these specifications, however, may not be as per the prevailing concepts and trends, and will have to be of comparatively simple and austere standards. These recommendations will therefore hold good only till shortages in availability of cement and steel continue.

0.8 The Committee places on record its appreciation of the preparatory work done by Shri R. G. Gokhale, Convenor and Shri B. V. Kulkarni, Member, as a result of which it became possible for the Committee to complete its task in a short time. The Committee also acknowledges valuable assistance rendered by Shri P. Padmanabhan, Executive Engineer of the Central P.W.D. in collecting and analysing the technical material that was required by the Committee and in the drafting of Report.

1. ARCHITECTURAL CONCEPTS, SPACE STANDARDS AND STRUCTURAL DESIGNS

1.1 ARCHITECTURAL CONCEPTS

1.1.1 *General.*—The Architectural design of a building, more or less determines the structural system on which depends the construction cost and quantum of cement and steel consumption. It is, therefore, necessary that a number of alternative concept studies are made to arrive at the most appropriate solution. From the very beginning, a close collaboration between Architects and Engineers of various disciplines is called for. In view of present shortage of cement and steel architectural concept should be based on a simple form of structure, making maximum use of locally available materials like stone, brick, lime, timber, roofing tiles etc. Special attention should be paid to proper orientation of buildings so as to minimise need for use of fins, louvers, sunbreakers etc., which otherwise add to cost. Use of expensive materials and rich specifications for finishes should also be avoided as far as possible.

1.1.2 *Planning & Architectural Design.*—Within the framework of space requirements in respect of essential uses and components as may be determined on the basis of prescribed norms, efficiency in site planning and design of individual building unit can considerably add to economy. For example, a narrow frontage in building plot would lead to economy in cost of services. Design efficiency of an individual unit is another aspect which has vital bearing on the economy of building construction. By careful planning of circulation spaces, judicious grouping of toilet facilities, design efficiency of a building could be considerably improved. Two Reports of the COPP Viz. Report on Multistoreyed buildings⁽¹⁾ and Report on Residential Buildings⁽²⁾, have studied these aspects in great

detail for residential and office buildings. These Reports, though brought out nearly 10—15 years back, form a good basis for laying down some standards for design efficiency. It is recommended that all large scale Construction Agencies should try to adopt them, with such modifications as may be considered necessary in the light of modern techniques and requirements. Also, NBO should update these reports as early as possible.

1.1.3 *Economics of Building Heights.*—Another important factor which influences the cost of a building is, whether it is a load-bearing wall structure or a framed structure. Generally speaking, framed structures are not required up to three storeyed construction where bricks of medium strength (70 Kg/cm^2) are available and spans are not large. Where good quality bricks (strength 105 Kg/sq. cm) are available, load-bearing structures are feasible up to 4 or 5 storeys and would result in saving of steel to the extent of 30 to 50 per cent and of cement to the extent of 15 to 25 per cent, as compared with RCC framed structures. For buildings with large spans and heights of 3 to 5 storeys, on structural consideration, it may be necessary to go in for a combination of load-bearing walls and RCC frames. When it is unavoidable, on considerations of cost of land and Master Plan density, to go in for buildings more than 5 storeys, and RCC framed structure is adopted, generally 7 to 8 storeyed construction would be found to be most economical. While considering economics of building construction *vis-a-vis* their height, type and cost of foundation should also be taken into consideration. Cost of buildings beyond 7 to 8 storeys generally rises steeply because of factors such as need for special types of foundations like Rafts, Piles etc., provision of High Speed Lifts, built-in Fire-Fighting arrangements like Wet Risers, Automatic Pumps, additional water storage facilities and Standby Generators etc.

It is common knowledge that double storeyed construction is usually most economical as far as building cost is concerned.

As the number of storeys increases, unit cost goes on rising. However, when the height of a building is low, the element of cost of land and external services is more. It is, therefore, necessary to decide the height of buildings after taking into consideration overall cost of construction, land, and services.

1.1.4 Doors and Windows.—In building construction, element of cost of doors and windows is quite significant. Areawise, the cost of doors and windows is three to five times the cost of walls. It is, therefore, necessary that number and size of doors and windows are kept to the minimum, consistent with the requirements for inter-communication, lighting and ventilation. In Hot and Dry regions, window area of 10 to 15 per cent and in Hot and Humid regions window area of 15 to 20 per cent of floor area would be adequate (2, 2). With the reduced floor heights, it is not necessary to provide fan lights or ventilators over doors and windows. In order to conserve use of steel and to bring down cost, use of steel and aluminium windows should be minimised. Economy can also be effected by avoiding expensive and decorative grills for windows and providing simple and functional grills to serve the need for security.

1.1.5 Standardisation.—An appreciable amount of economy in cost of construction as well as improvement in quality can be effected by standardisation in planning and designing of buildings. In standardisation, it is necessary to take into consideration availability of local materials, climatic conditions and living habits in various regions. Standardisation with modular coordination will greatly facilitate use of standard components such as doors, windows, precast flooring and roofing components, fixtures, fittings, floor tiles etc. and all major construction agencies should take necessary action in this regard. Whenever a large number of units of any particular type of building are to be constructed, it will lead to better results if a Prototype is first constructed, so as to decide upon the most suitable design and details.

1.2. SPACE NORMS

1.2.1 For residential buildings, the National Building Code (1) has laid down minimum area for habitable rooms, kitchen, bath-rooms and water closets. These should be adopted subject to changes as suggested in Chapter 6. For non-residential buildings, space requirements should be worked out on the basis of prescribed norms where available or on the analysis of activities required to be performed so that unnecessary space is avoided. Width of corridors and stair-cases should be determined with reference to the occupancy of the building as given in the National Building Code Part IV.

1.2.2 *Floor Heights.*—It was customary in the past to have liberal floor heights since overall height of buildings was not much and there was a belief that greater floor heights add to comfort in hot weather. It has been since established that excessive heights do not add to comfort and are, therefore, unnecessary. In case of residential buildings, a floor height of 2.75 metres (floor to ceiling) as stipulated in the National Building Code is adequate. Generally the same floor height of 2.75 m is also adequate for office buildings. However, where there are deep beams, a clearance of 2.25 m. should be provided below the soffit of beams. In buildings where provision for Central Air-conditioning is to be made, position and depth of air ducts should be taken into consideration while deciding the floor height and a clearance of 2.4 m. below false ceilings in office rooms and 2.25 m. in corridors should be provided. In regions of Temperate or Cold climate, where fans are not required, a floor height of 2.5 metres would be adequate. In hot and humid regions, in the case of top most storey, if the roof insulation is not adequate, the floor height may be increased by 15 cm.

1.3. STRUCTURAL DESIGN

1.3.1 *General.*—As the cost of structural fabric of a building depends much on the method of structural design adopted, it is necessary that Construction Agencies adopt the latest design

techniques in order to achieve economy in costs as well as in the use of Cement and Steel. These techniques and connected matters have been discussed in the following paragraphs.

1.3.2 Masonry Structures.—(a) In the past, thickness of walls used to be mostly based on thumb rules. A method for rational design of thickness of walls as given in the National Building Code (Part VI-Section 4) is now available, and should be adopted. This will lead to considerable economy in cost of buildings and consumption of cement. For internal load-bearing walls, thickness could even be half-brick where stresses are within permissible limits. In case of residences with rooms of small size, it has been found that 9" thick walls are adequate for 3 storeyed construction where crushing strength of bricks used is 70 Kg/cm². In places where bricks of 105Kg/cm² strength are available, 4 to 5 storeyed construction is feasible with 9" walls, using bricks of higher strength in ground floor. Where bricks of 105 Kg/sq. cm. strength are not available, it is also possible to design 4 to 5 storeyed construction using 70 Kg/sq. cm. bricks in all floors and providing plain cement concrete in highly stressed portions of the ground and first floor. In places where quality of bricks is very poor and more than two storeyed construction with load-bearing brick walls is not feasible, use of machine made hollow concrete blocks can be made with advantage up to 5 storeyed construction. Such construction will be more economical than RCC framed construction. Load bearing wall structures up to 4 storeys are feasible even in regions subjected to seismic tremors, provided certain precautions are taken as given in the National Building Code (Part VI—Sec. 4).

(b) It is necessary to plan a building in such a way as to utilise the strength of all the walls to the best advantage. Some of the basic principles to be kept in mind while designing buildings with load bearing walls are given below :—

- (i) Size and layout of rooms should be so adjusted as to give nearly uniform stress on all the walls of a storey.

- (ii) Transverse walls should be located so as to give support to the highly stressed section of walls.
- (iii) Walls should be placed concentrically one above the other for the full height of the building.
- (iv) Doors and windows and other openings in walls should, as far as possible, be kept away from corners and junctions.
- (v) As far as possible, chases in highly stressed portions of masonry should be avoided. While working out stresses in walls, chases if any, should be carefully taken into account.

1.3.3 Ultimate Strength Design of RCC Members (1,4).—This method of design takes full advantage of the strength of steel and concrete whereas in the traditional design based on elastic theory, stresses in steel are governed by the concept of modular ratio. This design approach will give significant saving in steel in members which require high percentage of reinforcement such as beams requiring compression reinforcement. Also substantial saving in steel is obtained in columns subjected to bending moments. Saving in steel in case of load bearing wall structures would be of the order of 10 per cent while in RCC framed structures it could be upto 20 per cent.

1.3.4 Yield-line theory for the design of RCC slabs(5).—Design of two-way RCC slabs by the Yield-line theory, a method recognised by the National Building Code, results in economy in consumption of steel, to the extent of 10 to 20 per cent depending on Loading, Span, Aspect ratio and boundary conditions. This method of design should, therefore, be adopted.

1.3.5 Use of High Strength Deformed Bars.—Use of high strength deformed bars in RCC structures with large spans designed by Ultimate Strength method results in a reduction in the consumption of steel to the extent of about 30 per cent. However, in case of RCC slabs of small spans where provision of

reinforcement is governed by consideration of maximum permissible spacing of bars or in case of Ties for RCC columns or stirrups for beams, use of Deformed bars is not of much advantage. At present, the production of high strength Deformed bars in the country is not adequate to meet the demand. This Committee endorses the recommendations of the "Committee on Economy in Consumption of Steel in the Country", that the annual production of High Strength Deformed bars should be increased.

1.3.6 *Concrete Mix.*—Economy in RCC framed structure depends to some extent on proper choice of concrete mixes for different members. Where members are carrying predominantly compressive loads, richer mix of concrete will lead to saving in cost. Further in large projects, it is desirable to go in for Controlled concrete rather than Nominal mix so as to achieve economy in use of cement.

1.3.7 *Prestressed Concrete.*—In RCC framed structures with large spans, use of Prestressed Precast beams can result in saving of steel. Where facilities for manufacture and erection of precast prestressed beams are available, this technique can be adopted with advantage, after careful analysis of economy in overall cost. This technique will be feasible only in projects of large magnitude.

1.3.8 *Steel Structures.*—As a general rule steel structures consume more steel and are costlier than RCC framed structures. As such, steel structures should be adopted only where other type of construction is technically not feasible. Recommendations regarding economy in Steel Structures are dealt with in Section 4 of this Report.

1.3.9 *Design Aids.*—(a) Details of Ultimate Strength Design and Yield Line Theory are available in Hand-books published by Structural Engineering Research Centre.^(4,5) However, to facilitate the use of latest methods of design by all Construction Agencies and private designers it is necessary to make available

design aids in the form of Data Sheets, Monograms, Charts, Tables etc. Early action in this regard should be initiated by N.B.O./I.S.I. in consultation with S.E.R.C.

(b) The Committee was informed that National Building Organisation has been conducting Workshops to acquaint Engineers with the design methods referred above. It is recommended that National Building Organisation should organise more of such Workshops throughout the country.

1.3.10 *Review of I.S.I. Codes and Standards.*—It is understood that Indian Standards Institution is already reviewing its Design Codes for increased permissible stresses in steel, reduction in Load Factors and downward revision of the Standard for Superimposed Loads. This Committee recommends that ISI should expedite this work and, pending revision of the Codes, should also examine possibility of laying down some interim reduction in the present Load Factors and Superimposed Loads.

2. MEASURES TO PROMOTE USE OF FLY ASH IN BUILDING PROJECTS

2.1 It has been established by research organisations that use of Fly ash of suitable quality can save cement to the extent of 15 to 20 per cent without any loss of strength or other detrimental effects. The main hurdle however which stands in the way of use of Fly ash in building construction is that there is a very great variation in the quality of Fly ash as it comes out from the stack of thermal power houses depending upon the nature and size of coal used, the type of combustion equipments, control of combustion process, uniformity of load, and mode of Fly ash collection.

As such, it is not possible to use Fly ash in building industry unless the Power House authorities take steps for setting apart that portion of their Fly ash production which conforms to standards as laid down by ISI or even some lower standards which may be acceptable to the construction agencies for less important items of works. It is therefore, recommended that Government should issue special directives to the various Power House authorities to the effect that they should take special steps to make available to Construction Agencies Fly ash of specified and uniform quality in collaboration with various large Construction Agencies. It may be added here that if Fly ash is not used in building industry it has to be disposed of as industrial waste and Power House authorities have to incur lot of expenditure on this disposal. If they take steps to make available Fly ash of specified and approved quality for building industry, they will in fact be effecting some economy in overall expenditure and would at the same time be helping the national cause of bringing about economy in the use of cement in the country.

2.2 Apart from the problem of marked variation in the quality of Fly ash, another problem which the construction agencies have to contend with is the difficulty of proportioning and mixing of Fly ash with cement at site. This imposes certain limitations in the use of Fly ash by direct mixing at site of work and therefore for optimum use of Fly ash in building industry it is recommended that (a) some centralised agency either in the private or public sector should set up ready mixed concrete plants using Fly ash in large cities where Fly ash is available within reasonable distance and (b) cement factories should be persuaded/encouraged to produce more and more of pozzolana cement making use of Fly ash.

2.3 Since adequate information and technical knowhow regarding the use of Fly ash in building industry is not readily available to various Construction Agencies, the Committee recommends that N.B.O. should collect, collate and disseminate information on the subject by publishing detailed technical note.

3. AMENDMENTS TO SPECIFICATIONS, RULES AND PROCEDURES OF PUBLIC WORKS DEPARTMENTS

3.1. SPECIFICATIONS

3.1.1 When production of cement and steel in the country was not much, specifications of various Public Works Departments and other Construction Agencies in the country generally covered use of materials like lime, surkhi, stone slabs, roofing tiles etc. As production of cement and steel in the country increased, building specifications utilising cement and steel came to be largely adopted and above mentioned materials fell into disuse. In the context of present shortage of cement and steel in the country, it has become necessary to make greater use of materials other than cement and steel. With this in view, alternative specifications of principal items of building construction, as indicated in Appendix-B should be adopted. These alternative specifications are generally applicable to simple buildings like Residences, Offices, Schools etc. and do not cover Industrial and other special structures. For adoption of these specifications, it is necessary for all the construction agencies to review their standard Specifications and to amend or amplify them where necessary. In this connection, it may be mentioned that the Indian Standards Institution have published Standard Specifications for most of the materials commonly available and a reference can be made to those Standards while amending/amplifying the existing Departmental Specifications. A list of relevant Indian Standards in this connection is given in Appendix-C.

3.1.2 Most of the materials included in the suggested specifications in para 3.1.1. are not available at present in adequate quantity and of acceptable quality in open market. Measures for increasing production of these materials and for improving quality have been discussed in Section 7 of the Report.

3.2. RULES AND PROCEDURES

3.2.1. The Committee did not come across any Departmental Rules and Procedures which may be standing in the way of greater use of local materials. In this context, it may be mentioned that as recommended in Section 7 of the report it will become necessary for Construction Agencies to go in for manufacture/procurement of certain materials on a large scale. Wherever the existing Departmental Rules do not provide for this, necessary amendments to the Rules and Procedures should be made.

3.2.2. It may not be out of place to mention here that use of materials like lime and surkhi in mortar for masonry and concrete will lead to slowing down of pace of construction since mortars and concrete using lime require more time for setting and developing strength. As such, longer period have to be allowed for in contracts where use of lime in place of cement for mortars and lean concrete is stipulated.

4. MEASURES FOR IMPLEMENTATION OF RECOMMENDATIONS OF THE 'COMMITTEE ON ECONOMY IN CONSUMPTION OF STEEL IN THE COUNTRY' RELATING TO BUILDING CONSTRUCTION

4.1. In order that recommendations of the 'Committee on Economy in Consumption of Steel in the Country'(7), in so far as these relate to building construction are implemented, it is necessary that these are given wide publicity and reach the officials of various Construction Agencies at different levels. The Report in question is fairly comprehensive and covers fields, such as Residential and Office Buildings, Industrial Structures and Sheds, Bridges, Railways Track and Wagons, Water Supply Installations, etc. More important recommendations of the Report relating to building construction have been reproduced in Appendix-D. The Committee endorses for adoption, the recommendations contained in this Appendix.

4.2. The Committee on Steel Economy in its Report has made certain recommendations in regard to the pattern of steel production as well as formulation of Indian Standards for "nearly parallel flange" sections. Ministry of Steel and Indian Standards Institution should expedite action on these recommendations.

4.3. It is also one of the recommendations of the Steel Economy Committee that Indian Standards Institution should review the loading standards and suitably revise the same. We have made a similar recommendation in para 1.3.10 of the Report. Indian Standards Institution may expedite action.

4.4. Another important recommendation of the Steel Economy Committee relating to building Construction, is the need for increase in the production of high strength deformed bars in the country as this would lead to considerable economy in consumption of steel and cost of construction. This point has already been discussed by this Committee in para 1.3.5 of this Report.

5. USE OF PRECAST BUILDING COMPONENTS

5.1. *General.*—In building construction, use of precast components would, generally speaking, lead to improvement in quality of concrete and to reduction in construction time as well as economy in use of material, in some cases. Improvement in quality is possible because components are manufactured under factory conditions, employing trained and skilled labour and appropriate tools and machinery. Economy in construction time is possible as work on manufacture of precast components can be done independently of the various construction operations at site. A comparison of consumption of cement and steel between cast-in-situ flooring vis-a-vis precast flooring has been brought out in Appendix-E.

5.1.1. Even though technique of precast construction has been known to engineering profession for quite some time, it has not been commonly adopted because of certain limitations such as unaesthetic look of the ceiling, inadequacy of sound and thermal insulation, low impact factor and proneness to water leakages on account of too many joints etc.

5.2. In the context of present shortage of cement and steel in the country, there is a need to go in for use of precast components in building projects of large magnitude wherever it is found economical. Details of some of the common types of precast units are given in the following paragraphs.

5.2.1. *Precast Doubly Curved Shells*(⁸).—Precast doubly curved shells are used either in conjunction with precast joists/battens or cast-in-situ ribs in two directions. Size of the shells is generally 1 m square, which can be handled manually. This type of construction does not give flush ceiling and for that reason has not been commonly adopted.

5.2.2. Precast Battens and Hollow Block Construction⁽⁹⁾.—In this type of flooring/roofing, hollow blocks of concrete or clay are supported on inverted 'T' battens and finished with concrete topping. The precast 'T' battens may be of RCC or prestressed concrete. These can be handled manually. This type of flooring/roofing gives a flush ceiling and has good thermal insulation and adequate sound insulation. They are not suitable for floors subjected to impact loads or vibration.

5.2.3. Precast cored Units⁽¹⁰⁾.—These are precast RCC units generally 30 cm. to 60 cm. wide having circular hollow cores along the length. These do not require any centring for laying. This type of flooring/roofing gives a flush ceiling and has adequate thermal and sound insulation. These units can also be made of prestressed concrete.

5.2.4. Precast Cellular Units⁽¹¹⁾.—In this system, unreinforced concrete hollow units are placed on fully or partially precast beams. The recommended size of the cellular units is 1 m × 50 cm × 10 cm or 1.2 m × 60 cm × 7.5 cm. The beams are placed at 1 m or 1.2 m centres. The cellular units can be handled manually. In this type of construction, precast beams project below the ceiling.

5.2.5. Precast Channel Units⁽¹²⁾.—These are precast RCC units, trough shaped in section and do not require any centring during erection. These units are made in widths varying from 30 cm to 90 cm. While smaller units can be handled manually, larger units require mechanical handling. Larger units are more economical in the use of steel. Thermal and sound insulation and fire rating of these units are less than that of solid RCC slab. These units can also be made of prestressed concrete.

5.2.6. Precast Lintels, Staircase Treads and Shelves. —Certain economy in cost and saving in construction time is possible by resorting to precast lintels, staircase treads and shelves.

5.3. In order to obtain satisfactory results, it is necessary that precast units are manufactured in well organised casting

yards using controlled concrete, steel moulds and vibrating tables. Use of precast units can therefore be adopted with advantage only where construction agencies have large scale programmes. To get the maximum advantage of the use of precast units in building construction, it is necessary to adopt building plans which are based on standardisation and modular coordination, so that variety of components is minimised.

5.4. It is necessary that precast units employed in flooring/roofing should have adequate performance values in regard to impact, sound insulation, fire rating etc. depending on the use to which the structure is to be put. At present no Code of Practice for performance standards of precast units is available. It is recommended that Indian Standards Institution should prepare Codes of Practice for performance Standards with various types of precast units.

6. NATIONAL BUILDING CODE

6.1. The National Building Code compiled and published by the Indian Standards Institution covers Building Regulations, Building Materials, Loading Standards, Design methods and provision of Services. The Code takes into account internationally accepted performance standards for buildings and serves as a guide and reference book to the Planners, Architects and Engineers.

6.2. From a study of the National Building Code it is seen that provisions in regard to minimum size of the kitchen and bathrooms are rather on the high side as far as small houses are concerned. The Code provides an area of not less than 5.5 sq. m. for the kitchen. This minimum area should be reduced 4 sq. m. with a width not less than 1.5 m. Again the Code provides a minimum area of 1.8 sq. m. for a bathroom. This could be reduced to 1.5 sq. m. with a width not less than 1.1 m. It is recommended that ISI should make the above modifications in the National Building Code.

6.3. Construction of buildings based on provisions of National Building Code (subject to amendment proposed by the Committee in para 6.2) in the matter of minimum size of rooms, minimum floor heights, window areas, thickness of walls and plumbing systems would result in economy in cost of construction as well as in use of critical materials. The building bye-laws of various local bodies, however, in many cases, are not in conformity with the provisions of National Building Code and call for review and modifications. It is understood that ISI is in touch with various Corporations and State Governments and is persuading/helping them to make suitable amendments to Building Bye-laws and Municipal Acts.

6.4. Provisions of the National Building Code are, however, set out mostly in the form of a technical manual and in a number of cases, they are full of cross-references and as such are not worded in a form for ready adoption as Building Bye-laws under the Municipal Acts. It is recommended that Model Building Bye-laws be prepared in a simple and statutory language incorporating essential provisions of the National Building Code by each State Government for adoption by various Local Bodies. This measure will ensure speedy adoption of the relevant provisions of the National Building Code by Local Bodies.

6.5. Since a comprehensive review and revision of Building Bye-laws and where necessary, Municipal Acts, is a time consuming process, it is recommended that each State Government may consider the desirability of enacting a Law empowering the State Government to notify that provisions of the Model Building Bye-laws as may be prepared as per para 6.4 shall be applicable to all or any Municipalities forthwith and to that extent the existing Bye-laws shall stand superseded.

6.6. Since revision of Corporation/Municipal Acts is a lengthy process, it is recommended that in future Corporation/Municipal Acts, technical provisions relating to minimum size of rooms, minimum floor heights, window areas, thickness of walls, plumbing systems etc. should form a part of the Bye-laws/Schedules so that these could be amended as and when found necessary without much delay or difficulty.

6.7. The Code has laid down standards for use of common materials such as lime, surkhi, flyash, stone, roofing tiles, commercial timber etc. It also permits use of any other material not covered by Indian Standards if they give satisfactory performance. As such no amendment to the Code is necessary as far as use of local material is concerned.

6.8. The National Building Code contains useful recommendations on methods of Structural Design, some of which have been

referred to in Section 1 earlier. It is recommended that all Construction Agencies should adopt provisions of the National Building Code relating to Structural Design so that economy could be achieved in design of buildings:

6.9. The National Building Code applies only to permanent structures. The present economic conditions in the country are, however, such that economically weaker sections of the community have to live in semi-permanent and temporary structures. There is hardly any regulation or control on the construction of semi-permanent and temporary structures in the country. Since we have to live with these structures in the country for some time to come, it is recommended that Building Bye-laws of Local Bodies should provide for construction of buildings with semi-permanent specifications in specified areas in towns and cities so that there may be some measure of Control and Regulation on such construction.

7. BUILDING MATERIALS.

7.1. For effecting economy in use of cement it is necessary that we ensure adequate production of good quality bricks, lime and surkhi. At present these materials are not available in adequate quantity and in many cases quality is sub-standard. It is, therefore, necessary to take special steps for increasing production and improving quality of these materials as discussed in the following paragraphs. In addition, there is a need for improving availability of timber in the country to meet the growing needs of the building industry.

7.2. *Bricks.*—The main difficulties in the production of bricks in the country, which have a bearing on quality as well as quantity are:

- (a) outmoded methods in vogue for manufacture of bricks;
- (b) shortage of coal of proper quality for burning of bricks;
- (c) policy of short-term licensing of land for brick kilns and;
- (d) inadequacy of land for setting up of brick kilns.

The Committee recommends that brick industry should be recognised as an organised industry and Government should give urgent consideration to the problem of supply and movement of quality coal for this industry. In urban areas, local or Town planning authorities should on basis of proper soil surveys and other considerations, set apart and allocate adequate areas of land for brick kilns and where necessary Government or local authorities should acquire such lands and lease them out for manufacture of bricks on long-term basis. With the help of

National Buildings Organisation, steps should be taken to improve the quality of production of bricks through establishment of semi mechanised/mechanised brick plants in large urban cities. Also State Governments should, through technical know how of N.B.O., set up pilot projects for Training and Demonstration in production of improved quality of bricks. If proper facilities are given, there may be no dearth of private entrepreneurs coming forward to manufacture bricks of improved quality. If however need arises production of bricks may be supplemented through public enterprise.

7.3. *Lime.*—Lime is the main substitute material for cement. Quality of lime produced, however, in the country is generally not good because of non-availability of good coal for burning and non-adoption of proper technique for manufacture. Lime is mainly available in the form of quick lime and, to some extent, in the form of hydrated lime. Use of quick lime, which cannot be stored for a long time, requires special arrangements for slaking and grinding at site of work while hydrated lime, which can be stored for longer periods, can be used directly for preparation of mortar or concrete at site. To ensure quality and speed in construction, it is desirable to use standard hydrated lime in bags. Some agencies like Central Building Research Institute and the Khadi & Village Industries Commission have evolved new designs for lime kilns and hydrators for manufacturing good quality hydrated lime; those designs could be adopted with advantage. Production of lime to a great extent suffers because of inadequate supply of good quality coal for burning of lime. It is therefore recommended that Government should allocate sufficient quantity of coal of proper quality for this industry. In order to improve quality, N.B.O. should set up Training-cum-Demonstration plants at various places in the country. It is understood that NBO is already setting up such a plant in Delhi in collaboration with National Building Construction Corporation. In case demand for this material cannot be met through private sector alone, large Construction Agencies like Public Works Departments, Housing Boards, Delhi Development Authority etc. should establish lime

manufacturing plants of their own to supplement the supply from the open market. Government may also consider possibility of advancing, loans through HUDCO or such other Financial Institutions, to private entrepreneurs for setting up modernised lime manufacturing plants.

7.4. Surkhi.—At present surkhi is being manufactured through grinding of brickbats. However, surkhi produced through this method is not of uniform quality and therefore construction agencies are hesitant to specify the use of this material in their building works. Quality of surkhi made from grinding of bricks depends upon the type of soil which is used for burning bricks. It is necessary therefore for construction agencies to make proper tests on surkhi produced from grinding of brickbats so as to ensure quality. This is one of the main limitations which stands in the way of general use of surkhi in building works.

Central Road Research Institute and National Buildings Organisation have evolved special techniques for manufacture of surkhi having high reactivity with lime. Use of this Reactive Surkhi in lime mortar gives good strength which is comparable to that of cement mortar. In order that lime could function as an effective substitute for cement, it is necessary, that the technique for manufacture of Reactive Surkhi should be popularised through setting up of Pilot-cum-Demonstration Plants with the help of NBO. The Committee recommends that large Construction Agencies like PWDs, Housing Boards, Development Authorities etc. should make arrangements for manufacture of Reactive Surkhi with the technical know-how of NBO.

7.5. SECONDARY SPECIES OF TIMBER

7.5.1. Primary species of timber used in building construction are now becoming scarce and costly. It is therefore necessary to popularise use of Secondary species in building construction so as to bring about reduction in the demand for primary species and also to bring down cost of construction. Forest Research Institute, Dehra Dun, after testing various species of timbers

have brought out that over 100 species of secondary timber in this country are suitable for use in building construction. Indian Standards Institution as well as National Buildings Organisation have also published detailed information in this regard.

7.5.2. In order to use Secondary species of timber in building construction, it is necessary that the timber should be properly seasoned and treated with preservatives so as to ensure adequate serviceability from these species. Since effect of preservative treatment is mainly on the skin layers, it is necessary that the timber should be given this treatment after it has been sawn to the actual sections to be used in construction. From this consideration, secondary species of timber can best be utilised in building industry if there are integrated plants for seasoning, treatment and fabrication. It is understood that about twelve such plants have already been set up in the country but their capacity is not being fully utilised. It is therefore recommended that large construction agencies should, in their future schemes, provide for joinery of secondary species of timber and should obtain their requirements of joinery from the plants already existing in the country. If need arises, more such plants could be set up later in the public sector.

7.6. *Stone Slabs.*—In certain areas stone slabs can be used in floors and roofs of buildings and as lintels to replace cement concrete. Though quarries of stone slabs suitable for use in buildings exist in several regions, the material is not readily available in the market in sufficient quantity due to want of regular demand. In places where it is economical to use stone slabs in place of RCC and Construction Agencies have large-scale programme of such construction, they should make advance arrangements for procurement of this material.

8. FOLLOW UP ACTION ON THE REPORT

8.1. *Implementation of recommendations of the Committee.*—

The Committee in the relevant sections of the Report has already indicated the steps that are required to be taken by the various authorities concerned with the issues brought out in this Report. Following are some of the more important recommendations on which immediate action is called for:—

- 1. Adoption of the alternative specifications as recommended by the Committee, for future projects by all Construction Agencies (Section 3).
2. Amendment of the National Building Code by I.S.I. and formulation of Model Building Bye-Laws by State Governments and where necessary special enactment by State Governments to enforce the provisions of Model Building Bye-laws on all Local Bodies (Section 6).
3. Adoption of measures for increasing production of materials like bricks, lime and surkhi, which are vital for bringing about economy in consumption of cement and steel (Section 7).

8.2. MONITORING

8.2.1. The Ministry of Works and Housing should set up a Unit under a technical officer in the Ministry to monitor progress on implementation of the various recommendations of this Committee by obtaining periodical reports (say quarterly) from all concerned and for dealing with various queries and comments that may be received on the Committee's Report. Also State Governments should be advised to set up similar Units in their Administrative Departments controlling PWDs for Building Works.

8.2.2. All Construction Agencies should be advised to have suitable set up in their Organisation to ensure effective implementation of the recommendations contained in the Committee's Report, by obtaining periodical Progress Reports, compiling information and forwarding reports to concerned Ministry/ Department of the Centre or State Govt. as referred to in para 8.2.1 above.

8.3. ADMINISTRATIVE MEASURES AND MISCELLANEOUS

8.3.1. For construction of buildings in the Private Sector, issue of cement is controlled through Civil Supply Departments of State Governments. In order to ensure that a proper check is exercised on the issue of cement permits, it is recommended that Civil Supply Offices controlling issue of cement should be assisted by technical officers who could lay down norms for consumption of cement for various types of buildings in different areas.

8.3.2. For burning of bricks, in different areas, some State Governments are releasing coal to brick manufacturers. In some States, price control orders are also in force. In order to ensure that bricks are of good quality and are manufactured on scientific lines, it is recommended that State Governments should associate technical officers having adequate experience and knowledge of brick technology with task of regulatory control of manufacture of bricks.

8.3.3. The Ministry of Works and Housing should give wide publicity to this Report and should make arrangements for supply of copies of this Report to concerned Ministries and Departments of Central Government, Bureau of Public Enterprises, D.D.A. HUDCO, State Governments and Housing Boards etc.

9. SUMMARY OF RECOMMENDATIONS

S. No.	Recommendation	Reference to para-graph
1	1. Architectural concepts should be such as to give the most economical structure; maximum use of local materials should be made in the construction; non-functional elements should not be provided; use of expensive materials and rich specifications for finishes should be avoided as far as possible	1.1.1
	2. Efficiency in site planning and design of individual building unit can considerably add to economy. The recommendations contained in COPP Reports viz. 'Report on Multistoreyed Buildings' and 'Report on Residential Buildings' should be adopted with such modifications as may be necessary. N.B.O. should update these recommendations as early as possible	1.1.2
	3. Upto three storeys, load bearing structures should be adopted; where bricks of higher crushing strength are available load bearing structures upto five storeys may be constructed. If higher structures are unavoidable in Metropolitan cities, 7-8 storeyed construction would generally be economical	1.1.3
	4. Number and size of doors and windows should be kept to the minimum consistent with functional requirements. Area of windows may vary from 10 to 20% of floor area depending upon the climate. Use of steel and aluminium windows should be avoided as far as possible. Simple window grills for security may be provided	1.1.4

1	2	3
5. Principles of standardisation and modular coordination should be followed while planning and designing of buildings. Wherever a large number of units of any particular type of building are to be constructed a prototype may first be constructed to decide upon the most suitable design and details.		
6. Adoption of minimum floor areas prescribed in the National Building Code, subject to modification suggested in para 6.2 in low cost housing, will result in economy. For non-residential buildings, areas should be as per prescribed norms where available or should be based on the analysis of activities to be performed so as to avoid provision of unnecessary space. Width of corridors and staircases should be decided with reference to the occupancy of the building.		1.2.1
7. Floor heights in buildings may be limited generally to 2.75 metres (floor to ceiling). For buildings where central air-conditioning is to be provided, the height may be such as to obtain clear headroom of 2.25m below false ceiling in corridor and 2.4m in rooms. Where there are deep beams, a clearance of 2.25m below the soffit of the beam should be provided.		1.2.2
8. Load bearing masonry structures should be designed according to National Building Code. Such buildings should be carefully planned so as to utilise the strength of all walls to the best advantage.		1.3.2
9. Ultimate strength design method should be adopted for RCC members and yield line theory should be adopted for design of two way RCC slabs.		1.3.3
		1.3.4
10. High strength deformed bars should be used as main reinforcement in RCC structures except for slabs of small span where mild steel bars should be used.		1.3.5

1	2	3
11. Use of richer mix of concrete for members carrying predominantly compressive loads, will lead to economy. In large projects, it is desirable to go in for controlled concrete		1.3.6
12. Precast prestressed beams may be used in RCC framed structures where it is feasible and found economical		1.3.7
13. Steel structures should be adopted only where other types of construction is technically not feasible		1.3.8
14. Design aids in the form of charts, monograms etc. for the latest methods of design should be published by NBO/ISI in consultation with S.E.R.C. and made available to all Construction Agencies and private designers. N.B.O. should organise more Workshops in various Parts of the country for acquainting the engineers with the new design methods		1.3.9
15. Pending revision of the relevant Codes, I.S.I. should consider making some immediate modifications to the prescribed Superimposed Loads and Load Factors in the existing Codes.		1.3.10
16. Government should issue directives to the various Power House authorities to the effect that they should take special steps to make available to Construction Agencies Fly ash of specified and uniform quality		2.1
17. Measures should be taken to produce more quantity of Pozzolana cement using flyash. Ready-mixed concrete plants should be set up in large cities where flyash is available within reasonable distance		2.2
18. National Buildings Organisation should collect, collate and disseminate technical knowhow regarding the use of flyash in building industry by publishing a detailed technical note.		2.3

1	2	3
19. Alternative specifications for principal items of building construction as given in Appendix-B should be adopted with a view to reduce using of cement & steel		3.1.1
20. Wherever the existing Departmental Rules do not provide for large scale manufacture/procurement of building materials like bricks, lime, surkhi, timber etc. necessary amendments to the Rules and Procedures should be made		3.2.1
21. Longer periods of construction have to be allowed for in contracts where use of lime in place of cement for mortars and lean concrete is stipulated		3.2.2
22. Important recommendations of the "Committee on Economy in consumption of Steel in the Country" in so far they relate to building construction have been examined and endorsed		4.1
23. The production of high strength deformed bars in the country should be increased		4.4
24. Precast floor/roof components may be used wherever found economical		5.1 to 5.2
25. To get the maximum advantage by use of precast units, building plans should be based on standardised units and with modular co-ordination		5.3
26. Indian Standards Institution should prepare Codes of Practice for performance standards of various types of precast units		5.4
27. The minimum size of kitchen specified in the National Building Code should be reduced from 5.5 sq. m to 4 sq. m. with a width not less than 1.5 m. For bathroom, the minimum area should be reduced from 1.8 sq. m. to 1.5 sq. m. with a width not less than 1.1 m.		6.2
28. Wherever the bye-laws of local bodies are different from provisions of the National Building Code (subject to amendment as proposed above) in respect of minimum room sizes, wall		

1	2	3
	thicknesses, floor heights and plumbing systems, suitable amendments should be made immediately.	6.3
29.	State Governments should prepare Model Building Bye-laws in simple and statutory language incorporating essential provisions of the National Building Code	6.4
30.	State Governments may consider the desirability of enacting a Law empowering the State Government to notify that provisions of the Model Building Bye-laws as may be prepared, shall be applicable to all or any Municipalities forthwith and to that extent the existing Bye-laws shall stand superseded	6.5
31.	Technical provisions should not form part of Corporation/Municipal Act. Such provisions should form part of the Bye-laws/Schedules so that these could be amended whenever necessary without procedural delays	6.6
32.	No amendment is required in the National Building Code for making greater use of local materials	6.7
33.	Building Bye-laws of Local Bodies should provide for construction of buildings with semi-permanent specifications in specified areas in towns and cities	6.9
34.	For increasing the production and improving the quality of bricks the Committee recommends that :	
	(a) the brick industry should be recognised as an organised industry.	
	(b) Urgent consideration should be given for the problem of supply and movement of quality coal for this industry.	
	(c) In Urban areas, local town planning authorities should set apart and allocate adequate areas of land for brick kilns.	

1	2	3
<p>(d) Land should be leased out on long terms basis.</p> <p>(e) State Governments should set up pilot projects with the help of N.B.O. for training and demonstration in production of improved quality of bricks.</p> <p>(f) If there is need, production of bricks may be supplemented through public enterprises.</p>		7.2
<p>35. For increasing the production and improving the quality of lime, the Committee recommends that</p>		
<p>(a) Government should allocate sufficient quantity of coal of proper quality for this industry.</p> <p>(b) N.B.O. should set up Training-cum-Demonstration plants at various places in the country.</p> <p>(c) Large Construction Agencies like P.W.Ds., Housing Boards, Development authorities etc. should establish lime manufacturing plants of their own to supplement the supply from open market.</p> <p>(d) Government may consider advancing loans through HUDCO or such other financial institutions to private entrepreneurs for setting up modernised lime manufacturing plants</p>		7.3
<p>36. The Committee recommends that</p>		
<p>(a) Construction Agencies should conduct proper tests on surkhi produced from grinding of bricksbats before using the same as a Pozzolana in lime mortar.</p> <p>(b) The technique of manufacture of Reactive Surkhi from burnt clay should be popularised through setting up of Pilot-cum-Demonstration plants with the help of N.B.O.</p>		

1	2	3
(c) Large Construction Agencies like P.W.Ds., Housing Boards, Development Authorities etc. should make arrangements for manufacture of Reactive Surkhi with the technical know-how of N.B.O.		7.4
37. The Committee recommends that large Construction Agencies should, in their future schemes, provide for joinery using secondary species of timber and should obtain their requirements of joinery from wood-working plants already existing in the country. If need arises, more such plants could be set up later in the public sector.		7.5
38. In places where it is economical to use stone slabs in place of RCC and Construction Agencies have large-scale programme of such construction, they should make advance arrangements for procurement of this material		7.6
39. The Ministry of Works & Housing should set up a Unit under a technical officer in the Ministry for monitoring the progress on implementation of the various recommendations. State Governments should also set up similar Units		8.2.1
40. Construction Agencies should have suitable set up for ensuring effective implementation of the recommendations contained in this Report		8.2.2
41. Civil Supply offices controlling issue of cement for private construction should be assisted by technical officers who could lay down norms for consumption of cement for various types of buildings in different areas		8.3.1
42. State Governments should associate technical officers having adequate experience and knowledge of brick technology with the task of regulatory control on manufacture of bricks.		8.3.2
43. Ministry of Works & Housing should give wide publicity to this Report and make arrangements for supply of copies of the Report to all concerned		8.3.3

APPENDIX A1

GOVERNMENT OF INDIA MINISTRY OF WORKS AND HOUSING

No. N-16012/1/73-PS

New Delhi, the 8th July, 1974

ORDER

SUBJECT : *Appointment of technical committee to draw up guidelines for economy in the use of cement and steel.*

The Government of India are considering actively measures aimed at reducing the cost of construction and economising in the use of cement and steel. As a step in that direction, the Government of India have decided to set up a Technical Committee to draw guidelines regarding the changes required in architectural concepts, structural designs and space standards of ordinary buildings to allow for greater use of local materials.

2. The composition of the Committee is as follows:—

- | | | |
|--|-------------------------|------------------------|
| (i) Engineer-in-Chief, C.P.W.D. | Chairman | (Shri M.S. Bhatia) |
| (ii) Adviser (Constn.), Bureau of Public Enterprises. | Member | (Shri V.R. Vaish) |
| (iii) A representative of Engineer-in-Chief, Army Headquarters. | Do. | (Birg. Harish Chandra) |
| (iv) Chief Architect, C.P.W.D. | Do. | (Shri J.M. Benjamin) |
| (v) Shri Kulbir Singh, Chief Engineer, Chandigarh. | Do. | |
| (vi) Shri K.R. Ramaswamy, Retired Chief Engineer, Slum Clearance Board, Tamil Nadu. | Do. | |
| (vii) Director, National Bldg. Organisation. | Do. | (Shri Rabinder Singh) |
| (viii) A representative from Indian Standards Institution. | Do. | (Shri D. Ajitha Simha) |
| (ix) Shri R.G. Gokhale, Chief Engineer, C.P.W.D. (Now Chief Engineer, Delhi Administration). | Convener | |
| (x) Chief (UD), Planning Commission | Member and Jt. Convener | (Shri P. C. Khanna) |

3. The terms of reference of the Committee are as follows:—

- (i) To study and recommend changes required in architectural concept, structural design and space standards for ordinary buildings to allow for greater use of local materials like lime, surkhi, stone, tiles, timber etc. to ensure economy in the use of cement and steel and measures for getting these changes accepted and implemented.
- (ii) To recommend operational measures which would allow for immediate use of flyash in civil works of P.W.Ds., Public Sector Undertakings and other Govt. works.
- (iii) To recommend amendments to P.W.D. and departmental specifications, rules and procedures to allow for greater use of local materials referred to in (i) above.
- (iv) To examine and suggest measures for implementation of the recommendations of the Committee on economy in consumption of steel in the country in so far as they concern building construction.
- (v) To study the technical feasibility and suggest use of pre-cast building components like channel units, cored units, battens and hollow blocks and cellular units with a view to reducing consumption of cement and steel *vis-a-vis* conventional RCC construction.
- (vi) To recommend amendments to National Building Code so as to include provisions for greater use of local materials and simplification of the relevant parts of the Code to facilitate their adoption by local authorities.

4. The Committee should submit an interim report to Government within a period of three months from the date of issue of this order and final report within six months.

5. The Committee will be free to lay down the methods of its working and other procedural matters.

The Committee will work under the auspices of the C.P.W.D. which will also meet the costs of the Committee on travel, stationery etc. from within the sanctioned budget grant. The expenditure involved should be debited to the Head "Other Charges of the C.P.W.D.—Major Head 259, Demand No. 89".

Sd/- R. GOPALASWAMY,
Joint Secretary to the Govt. of India

APPENDIX-A2

GOVERNMENT OF INDIA
MINISTRY OF WORKS AND HOUSING

No. N-16012/1/73-PS.

New Delhi, the 24th August, 1974.

ORDER

SUBJECT : *Inclusion of additional members in the technical committee to draw up guidelines for economy in the use of cement and steel.*

The Government of India have decided that the under-mentioned officers should be included in the technical committee set up in this Ministry's Order No. N-16012/1/73-PS, dated 8-7-1974 and that their names should be added to the existing list in para 2 of the said order as indicated below:—

- (xi) Shri B.G. Baljekar, Managing Member
Director, Hindustan Steel Works
Construction Ltd., Calcutta.
- (xii) Shri K.G. Salvi, Managing Director, Hindustan Housing Factory Ltd. Member
- (xiii) A representative of Civil Engineering Wing of the P & T Member (Shri K. Rama Ver-
man)
- (xiv) A representative of the Railway Board. Member (Shri T.M. Thomas)
- (xv) *Shri B.V. Kulkarni, Chief Engineer (Central Designs Organisation, C.P.W.D. Member

Sd/ R. GOPALASWAMY,
Joint Secretary

*Shri V. Narayanan took over charge as Chief Engineer (C.D.O.) from 26th September, 1974.

APPENDIX B

PROPOSED SPECIFICATIONS TO MINIMISE USE OF CEMENT, STEEL AND OTHER CRITICAL MATERIALS IN BUILDINGS

<i>Items :</i>	<i>Specifications :</i>
1. Foundation Concrete	Lime concrete using surkhi, sand, cinder or suitable mixture of these depending on availability and quality of the materials, coarse aggregate to be brick or stone ballast according to availability and local costs. (Please see Notes 1, 2 and 3 below)
2. Mortar for Masonry in Foundation, Plinth and Superstructure.	Mud Mortar (For single storey construction where suitable soil is available). Lime : Sand 1 : 3 to 1 : 2 Lime : Flyash : Sand 1 : 1 : 2 to 1 : 1 : 1 Lime : Surkhi : Sand 1 : 1 : 2 to 1 : 1 : 1 Cement : Lime : Sand 1 : 3 to 1 : 1 : 6 Please see Notes 2, 4, 5 and 6)
3. Lintels	(i) Flat or segmental arches in brick work upto 1 metre span. (ii) Precast RCC Lintels designed on the principle of composite action between lintel and brick work (15). (iii) RCC lintels based on conventional design to be used where (i) and (ii) above are not feasible.

NOTES:—

1. In areas where soil is poor (e.g. black cotton soil) plain or reinforced cement concrete may be used in foundation if it is unavoidable on structural considerations.
2. Lime mortars are subject to attack by sulphate action which may arise if bricks contain soluble sulphates, or if soil contains soluble sulphates which would find way into the masonry/concrete, in foundation and plinth in localities of high water table. (14).
3. Mix proportions of lime concrete for foundation may be decided to suit local conditions after conducting tests.

4. Floors/Roofs .
- (i) Stone slabs on timber or precast RCC joists (16)
 - (ii) Brick Tiles on RCC or timber joists (17)
 - (iii) Timber Floors
 - (iv) Jack arches with RCC joists (18)
 - (v) Brick-cum-Concrete composite (Madras Terrace) floor or roof (19)
 - (vi) Reinforced brick or reinforced brick concrete, slabs (20).
 - (vii) Various types of precast units such as channel units, cored units, cellular units with RCC joists, hollow concrete/clay blocks with precast RCC/pre-stressed joists, doubly curved shells and waffle units for span more than 6 m.
 - (viii) Sloping roofs using Mangalore tiles, Allahabad tiles, slates or shingles over wooden trusses.
 - (ix) CGI/AC sheet roofs over wooden trusses.
(Please see Notes 7, 8 and 9).

NOTES :-

4. Proportion of mix for lime mortar should be decided after taking into consideration quality of lime and fine aggregate and design strength of mortar/masonry.
5. Generally lime mortar without any cement should be used in all masonry walls of buildings upto two storeys and also in non load-bearing walls like partitions, or filler walls. For load-bearing walls of buildings of more than two storeys, composite cement-lime mortar may be used, the proportion being determined according to the strength required.
6. When for structural reasons, brick walls are reinforced, the mortar used may be composite cement-lime mortar.
7. For floors and roofs, stone slabs or Tiles on timber/RCC joists, Jack arches, Madras terrace or other specification which require only small quantity of cement and steel should be preferred where suitable materials are available. Sloping roofs with tiles, slates or shingles should be adopted in regions where these materials are economically available and where their use is suitable for local climatic conditions.
8. Where precast RCC units are functionally and structurally suitable and where their use will result in economy of cement/steel, they should be preferred to cast in situ R.C.C. constructions.
9. Where local materials mentioned above are not economically available, and do not meet the functional requirement of any particular building R.C.C. construction may be adopted.

5. Flooring

- (a) Base for Ground floor . Lime concrete as in item 1.
- (b) Wearing Course . . . (i) Flat brick tiles laid with 12 mm thick joints grouted with mortar and finished with 12 mm thick plaster of cement mortar (1:4) in ground floor of low cost housing (Not suitable in areas like W.C. bath and Kitchen).
- (ii) Burnt clay flooring tiles (IS : 1478-1969).
- (iii) Stone slabs as locally available.
- (iv) Timber flooring.
- (v) Cement concrete/mosaic/terrazo tiles flooring to be provided when it is not possible to adopt any of the above alternative specifications on functional and cost considerations.

6. Plaster

- (a) External Cement lime mortar 1 : 2 : 9 to 1:1:6 depending on intensity of rainfall and quality of bricks.
- (Please see Notes 10 and 11 below).
- (b) Internal (i) Lime : Sand 1:3 to 1:2
- (ii) Lime : Surkhi : Sand 1:1:2 to 1:1:1
- (iii) Lime : Flyash : Sand : 1:1:2: to 1:1:1
- (iv) Lime : Surkhi 1:2
- (v) Where good lime is not available and where functionally needed, cement lime mortar 1:1:6 to 1:2:9 may be used.
- (Please see Note 10 below).

NOTES :-

10. External plastering need not normally be provided on stone work and only pointing shall be provided with lime or cement lime mortar.
11. In regions of low rainfall, if the bricks are of reasonably good quality, only pointing may be done externally with lime or cement lime mortar.
12. In areas subjected to continuous wetting such as bathrooms and kitchens, mortar for plaster used should be of comparatively greater strength.

7. Doors and Windows :
- (a) Frames and shutters To be made of recognised secondary species of timber, seasoned and treated.
(Please see Note 13 below).
- (b) Fittings For purpose of economy, costly fittings such as Brass/Aluminium should be avoided.
8. Drive-ways and Courtyards Any specification based on the use of stones, bricks lime etc., avoiding use of cement.
9. Plumbing (i) Plastic pipes may be used for low cost Housing Schemes.
(ii) Single stack system of plumbing, where Building By-laws permit.
10. Electrical Installations (i) Surface wiring on wooden battens shall be provided as far as possible.
(ii) When conduit wiring is essential PVC conduits may be used.

NOTE :—

13. Where soil is infested with termites, soil and timber should be subjected to Anti-termite treatment.

APPENDIX C
LIST OF SOME OF THE INDIAN STANDARDS ON BUILDING
MATERIALS

S. No.	I.S. No.	Title
(1)	(2)	(3)
<i>Pozzolanas</i>		
1.	IS : 1344—1968	Specification for burnt clay pozzolanas.
2.	IS : 3812 (Part I) 1966	Specification for fly ash. For use as pozzolana.
3.	IS : 3812 (Part II) 1966	Specification for fly ash. For use as admixture for concrete.
4.	IS : 3812 (Part III) 1966	Specification for fly ash. For use as fine aggregate for mortar.
<i>Building Limes</i>		
5.	IS : 712—1973	Specification for building limes.
6.	IS : 1624—1960	Code of practice for field testing of bulding lime and lime mortar.
7.	IS : 2686—1964	Specification for cinder aggregate. For use in lime concrete.
8.	IS : 3068—1965	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete.
9.	IS : 3115—1965	Specification for lime-cement-cinder solid blocks.
10.	IS : 4098—1967	Specification for lime-pozzolana mixture.
11.	IS : 3182—1967	Specification for broken brick (burnt clay) fine aggregates for use in lime mortar.
<i>Stones</i>		
12.	IS : 1124—1957	Method of test for water absorption of natural building stones.

(1)	(2)	(3)
13. IS : 1125—1957	. . .	Method of test for weathering of natural building stones.
14. IS : 1126—1957	. . .	Method of test for durability of natural building stones.
15. IS : 1128—1957	. . .	Specification for lime-stone slabs.
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APPENDIX D

IMPORTANT RECOMMENDATIONS OF THE "COMMITTEE ON ECONOMY IN CONSUMPTION OF STEEL IN THE COUNTRY" WITH REFERENCE TO BUILDING CONSTRUCTION

Residential and Office Buildings

1. Where good bricks are available load bearing masonry structures without reinforced concrete columns and beams may be provided in low rise buildings, say upto 4 storeys, depending upon the strength of bricks. In the case of office building where larger rooms are required, a combination of reinforced concrete frames and load bearing walls may be adopted, if necessary (5.1.1).

2. Where adoption of framed structures for multi-storeyed buildings is unavoidable, this may be of reinforced concrete construction generally. Where buildings have a large service core to serve as a stiff shear wall, combination of RC frames and shear walls may be used. In other cases "framed tube", "tube-in-tube" and "Bundled tube" system may be suitable depending upon the height of the building. (5.1.2).

3. Jack arches with RC supporting beams are recommended for adoption in floors and roofs of bldgs., with load bearing walls, in lieu of RC beam and slab construction, as far as possible (5.1.7).

Industrial Structures, storage sheds and other similar structures

4. At present a majority of industrial structures storage sheds and similar structures are of conventional designs with steel columns treated as propped or free vertical cantilevers and simply supported roof trusses. This type of construction may be avoided. Instead they can be planned either as completely RC structures or partly RC and partly steel constructions. Even in industrial structures with cranes of upto medium capacity RC columns may be used, instead of steel, leading to economy in consumption of steel. (5.2 and 5.2.5).

5. All structures may be constructed, as far as possible, only as RC rigid frames with deformed bars as main reinforcement. Till such time deformed bars become available in requisite quantity, mild steel plain round bars may be used. (5.2.1).

6. Shell and folded plate structures consume minimum amount of cement and steel compared to any form of RC construction. These will be suitable only if a large number of identical units are to be constructed. Large workshop structures where this condition is fulfilled may be constructed as doubly curved shells, such as hyperbolic paraboloid, conoid and hyperboloid shapes which can be cast on forms composed of straight planks, being ruled surfaces (5.2.2).

7. Precast and prestressed corrugated shells, funicular shells and hyperboloid shells and PC trusses may be used for storage sheds replacing steel structures. Prestressed shell elements may be prestressed in the longitudinal direction as well for connecting them. A saving of steel upto 50 percent can be expected with these systems. These may be standardised by ISI in consultation with SERC and suitable design aids furnished to the users. Standardisation will help the industry to manufacture the precast products and make available as ready made units in the country (5.2.3).

8. Funicular shells with bricks are suitable for use in storage sheds and industrial buildings without crane loading. National Building Organisation may, in consultation with SERC, publish literature on the subject for its large-scale adoption (5.2.4).

9. Only in those cases where the methods mentioned above are not feasible, structures made of new steel may be resorted to. In all such cases welded construction instead of rivetting should be the normal practice and the structures designed as rigid frames by plastic theory where possible. In industrial buildings with overhead cranes, where designs cannot be based on plastic theory, it is recommended that welded rigid frames structures designed on elastic theory may be adopted. In these cases also use of tubular/hollow sections has to be preferred to that of plates and structurals. If used for heavy construction, the field connections could be welded or with friction grip fasteners. Use of light gauge structural in preference to rolled structural sections is recommended only where the use of tubular sections is not feasible.

Open web structures of either tubes or angles and bars, open web joist with concrete flange and castellated beams can be used as long span purlins, roof trusses in medium span storage buildings and in lightly loaded locations. ISI may standardise these systems in consultation with SERC (5.2.7 to 5.2.10).

Water Supply Installation

10. PVC and AC pipes may be used substituting steel pipes upto a dia of 315 mm. It is necessary to develop an efficient and effective method of joining PVC pipes. The ISI may take urgent action to finalise the codes for PVC pipe fittings and their laying and joining. Rate contracts may be concluded by the DGS & D and suitable instructions issued by Govt. Organisations for their adoption. (5.5.1 and 5.5.2).

11. PC and RC pipes may be used replacing large diameter pipes. ISI can standardise these products, in consultation with the Ministry of Works and Housing and C.P.H.E.R.I. Nagpur (5.5.2).

12. Water tanks and stagings may, as far as possible, be constructed of RC with high strength deformed bars as main reinforcement. Use of RC tanks may not, however, be practicable in railway yards, where these tank might have to be dismantled and shifted to provide for any future yard re-modelling required. (5.5.3).

APPENDIX—E

TABLE—1

Quantities of Cement and Steel required for different designs of RCC slabs per Sq. M. of slab area

Span 3.5 to 3.6 M.

S. No.	Type of slab and design method	Cement* Kg/m ²	Mild Steel Kg/m ²	Remarks
1.	One way slab (Elastic Theory)			
	(a) Simply supported	45.27	7.90	
	(b) Continuous	42.07	6.95	
2.	One way slab (Ultimate Strength Design)			
	(a) Simply supported	42.07	7.35	
	(b) Continuous	35.67	7.55	
3.	Two way slab (Working Stress Design)			
	(a) Simply supported	38.87	6.80	
	(b) Continuous	35.67	6.40	$\frac{L_y}{L_x} = 1.33$
4.	Two way slab (Ultimate Strength Design)			
	(a) Simply supported	38.87	5.95	—do—
	(b) Continuous	35.67	4.98	—do—
5.	Two way slab (Yield Line Theory)			
	(a) Simply supported	38.87	5.23	
	(b) Continuous	35.67	4.17	

*The quantities indicated include cement required for rendering the soffit.

APPENDIX E—contd.
TABLE—2.

Quantities of Steel and Cement required for different types of Precast Floor construction per Sq. M. of floor area
Span 3.5 to 3.6 M.

S. No.	Type of construction	Cement Kg/m ²	Steel (Kg/m ²)			Remarks/Source
			M.S.	H.T.Wire	Total	
1.	Cored units (RCC) 0.30 Metre wide	28.50	7.70	—	7.70	CBRI data sheet 3
2.	Cellular units 1.2 m × 0.6 m × 7.5 cm. on precast RCC joists	35.50	6.28	—	6.28	CBRI data sheet 4 RCC joist designed in CDO
3.	Channel Units :					
	(a) 0.30 metre wide	22.20	6.03	—	6.03	CBRI data sheet 5
	(b) 1.00 metre wide	22.60	5.34	—	5.34	Designed in CDO
4.	Waffle shells (size of shell 1.1' m × 1.1' m)	31.20	5.32	—	5.32	G.S. Ramaswamy's lecture note on economy in the use of steel in Building construction N.B.O., Sept., 1973
5.	Cored Units (Prestressed)					
	(a) 0.30 metre wide	55.00	2.60	1.70	4.30	Hindustan Housing Factory
	(b) 0.60 metre wide	51.00	3.00	1.40	4.40	
6.	Hollow block and Prestressed battens	46.00	3.00	1.00	4.00	Hindustan Housing Factory. Cement includes requirement for 40 mm. topping and 12 mm. ceiling plaster.
7.	Channel units (Prestressed)					
	(a) 0.30 metre wide	34.00	2.20	1.70	3.90	Hindustan Housing Factory.
	(b) 0.60 metre wide	30.00	2.30	1.40	3.70	

APPENDIX F

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