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SRI LANKA STANDARD 365 : 1975

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STANDARD RECOMMENDATIONS FOR MODULAR CO-ORDINATION APPLICATION OF TOLERANCES IN THE BUILDING INDUSTRY

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BUREAU OF CEYLON STANDARDS

RECOMMENDATIONS FOR MODULAR CO-ORDINATION APPLICATION OF TOLERANCES IN THE BUILDING INDUSTRY

SLS 365 : 1975

~~Price Rs. 7/50~~

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This Standard does not purport to include all the necessary provisions of a contract.

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SRI LANKA STANDARD RECOMMENDATIONS FOR MODULAR CO-ORDINATION APPLICATION OF TOLERANCES IN THE BUILDING INDUSTRY

FOREWORD

This Sri Lanka Standard was prepared by the Committee for Modular (Dimensional) Co-ordination, under the authority of the Civil Engineering Divisional Committee of the Bureau of Ceylon Standards and was approved for adoption and publication by the Council of the Bureau on 1975-12-03.

Dimensional co-ordination cannot be achieved in buildings by the adoption of recommended modules alone. Dimensional deviations both in the manufacture and location of components are inevitable. Thus, for a practical realisation of dimensional co-ordination in the building industry, it must be supplemented with a system of tolerances adapted to this purpose. This recommendation deals with a means of containing dimensional deviations within pre-determined limits, so that co-ordination of dimensions can be realised in the end result; the building. Appendices relating to Methods and tools for setting out location dimensions at site and modifications required in the application of the "Additional Principle" are also included.

This Standard is one of a series of Sri Lanka Standards on modular co-ordination. Other Standards published so far in the series are :

CS 129 : 1972 Specification for 'Basic Module' to be used in the building industry ;

CS 130 : 1972 Specification for Horizontal Multimodules to be used in the building industry ;

CS 131 : 1972 Glossary of terms used in the building industry with special reference to modular co-ordination;

CS 132 : 1972 Classification of building components for dimensional co-ordination ;

C.S ....Controlling dimensions.

In the preparation of this standard, the assistance derived from the publications of the British Standards Institution and the Danish Standards Association, is acknowledged.

1. SCOPE

This Standard recommends a general system of tolerances for use in the building industry. The system is applicable to :

(*a*) the design of components.

(*b*) the design of a building incorporating pre-fabricated components.

(*c*) the assembly of components and placement of in-situ building operations.

A mathematical principle governing the summation of tolerances is also covered in this standard.

2. DEFINITIONS AND SYMBOLS

2.1 **Definitions** — For the purpose of this standard definitions as given in CS 131 : 1972* shall apply.

2.2 **Symbols** — The various symbols used in this standard shall denote the quantities given below against each :

T = Tolerance
D = Deviation
L = Work-size
G = Co-ordination gap

Suffices used are :

m = manufacturing
l = location
max = maximum
min = minimum

* CS 131 Glossary of terms used in the building industry with special reference to modular co-ordination.

3. DESIGN OF COMPONENTS

3.1 In designing the components consideration shall be given to :

(a) The magnitude of manufacturing tolerance required for economical and rational manufacture of the component.

(b) The magnitude of the location tolerance required for rational assembly of the component on the site.

(c) The largest and smallest practicable joint thickness between the component and adjacent components.

Production methods, and assembly or construction techniques usually determine the lower limits for manufacturing tolerances and location tolerances respectively. When such technical factors as thermal and moisture movement of the material have been given due consideration, values may be selected for the tolerances. In fixing tolerances, the values of manufacturing tolerances, location tolerances and joints should be considered collectively wherever possible, since they are often interdependent. It is necessary that the advantages (aesthetic or functional) of fine tolerances be weighed against the cost of achieving such tolerances in manufacture and assembly. As a general rule, all tolerances should be chosen to be as coarse as circumstances permit.

The method of calculating sizes is shown graphically in Fig. 1. The dimensional specification of a component must state :

(1) Co-ordinating dimension, of the component.

(2) Work size of the component.

(3) The manufacturing tolerance.

(4) The location tolerance of the component, if applicable.

(5) That the system of tolerances conform to that stated in this recommendation.

Manufacturing tolerances are stated symetrically in relation to the work size of the component, so that if L denotes the work size, and T_m the manufacturing tolerance, these dimensions may be specified as :

$$L \pm \frac{T_m}{2}$$

3.2 **Incorporation of pre-fabricated components in the design of the building** — In the dimensioning of preliminary design drawings only the co-ordinating dimensions of the components, obtainable from the manufacturer's catalogue, need to be considered. However, when detailed drawings and constructional working drawings, are being prepared, careful attention should be paid to manufacturing and location tolerances. This would enable the designer to predetermine the limit sizes of the joints that may occur and to ensure that the required "fit" is obtainable.

3.3 **Assembly of components and placement of in-situ building operations** — When the location tolerances have been determined the location dimensions should be chosen with care so as to ensure the following :

(*a*) Unambiguity ;

(*b*) Rational setting out of components ;

(*c*) Rational checking of dimensions at site.

In general, location dimensions are given with reference to modular points, lines or planes. When marking out these dimensions, they should, if possible be measured from one datum. If this is impracticable care should be taken to minimize cumulative errors. Methods and tools for setting out such dimensions are given in Appendix A.

Set out components always by reference to the grid lines and not to completed works. It is also important that the correct gaps are maintained between grid lines and corners. Ensure after positioning the components that the gaps are within the specified grid line. It is only necessary to check the minimum gap between a component and its grid-line, then the maximum gap will look after itself at the other end if the component is within its proper limits.

4. SUMMATION OF TOLERANCES

When a part or the whole of a building is assembled, the overall dimensions of the assembly will be the algebraic sum of the dimensions of the individual work processes ; e.g. if the assembly is entirely of pre-fabricated components, the linear dimensions of the assembly will be the sum of the linear dimensions of the individual components plus those of the joints between them.

The tolerances on the dimension of the assembly (sum tolerance) and the tolerance on the dimensions of individual work processes (part tolerances) are interdependent.

For the series of part-tolerances, T_1. T_2,....................T_n, the maximum dimensional deviation of the assembly (A) involving these tolerances is given by :

$$D_{max\ (A)} = \pm \tfrac{1}{2} (T_1 + T_2 + \ldots\ldots\ldots\ldots T_n)$$

The sum tolerance (T_s) may be chosen to be twice the value of the maximum deviation of the assembly.

1. Co-ordinating space
2. Co-ordinating dimension
3. Co-ordinating gap (Minimum)
4. Location tolerance
5. Maximum size of component
   $S_{max} = nM - 2G_{min} - T_l$
6. Manufacturing tolerance
7. Minimum size of component
   $S_{min} = nM - 2G_{min} - T_l - T_m$

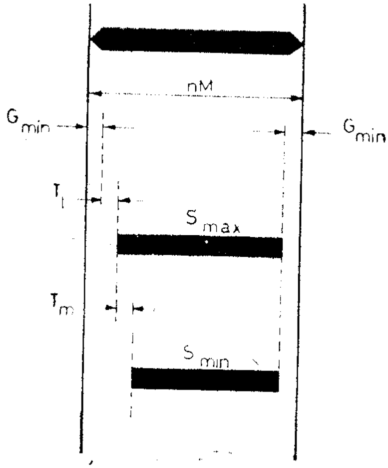

Fig. 1 — Calculation of sizes.

$$\text{i.e.} \quad D_{max\ (A)} = \pm \tfrac{1}{2} T_s$$

$$\text{Then } T_s = T_1 + T_2 + \ldots\ldots\ldots\ldots + T_n$$

If part tolerances T_1, T_2,...........,T are to be chosen on the basis of a given sum tolerance (T_s), the following condition must be satisfied.

$$T_1 + T_2 + \ldots\ldots\ldots\ldots T_n \leqq T_s$$

This relationship between part and sum tolerances is known as the "Additional Principle". Modifications that may be required in connection with the application of this principle are given in **Appendix B**.

APPENDIX A

METHODS AND TOOLS FOR MARKING OUT DIMENSIONS AT SITE

A—1 **General**—In the attempt to keep dimensions within the required accuracy it will normally be less satisfactory to work on the building site than in the proceeding steps in the building process (workshop and factory work).

At the same time the necessity of accurate marking out of dimensions and accurate placing of components will be accentuated, because at this stage of the building process undesirable deviations can no longer be resolved by planning or design.

In order to obtain the required accuracy of work on the building site, the appropriate methods and tools for measuring must be used.

A—2 **Marking out of dimensions**—The possibility of maintaining dimensions with the required accuracy during construction depends on which techniques are used in the marking out of dimensions (and control of dimensions).

The principle possibilities in practice will normally be the following :

1. Measuring from an (adjusted)* reference point, line or plane.
2. Measuring from already placed building parts and components (i.e. from their actual positions, which perhaps are encumbered with deviations).
3. Additionally, components will often be placed without proper marking out of dimensions, as their placement is exclusively dependent upon assembly methods.

In order for adjusted reference points, lines and planes to be satisfactory for "accurate" placement of components, it is necessary that the marking out of dimensions be done with precision instruments. Many of the methods and tools, that traditionally have been used in the past are no longer satisfactory and more precise measuring methods and tools should be used.

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* 'Adjusted references' means secondary references derived from the principal reference system.

The layout of reference points, lines and planes on the building site should be done with the aid of such instruments as levelling instruments, angle prisms, and theodolites. Marking out of dimensions should be done with steel tapes and the like. Establishment of lines and directions should be done with instruments such as plumb bobs and chalk-lines, and the actual marking with a steel stylus or by chalk-line "snapping".

(Mounting of load-bearing components for the main structural framework of a building should always be done in relation to adjusted reference points, lines and planes, and precision instruments must be used for measuring. This is necessary because the load-bearing components, when brought into position will often be used as the basis for marking out of dimensions in subsequent steps of the work.)

When dimensions are marked out from already placed components, it will often be advantageous to again use the above mentioned precision instruments for measuring. However, as the components that are placed in the later part of the building process will generally be less used as a starting point for additional marking out of dimensions, it is acceptable in this case to use less precise measuring methods and tools. In these cases, satisfactory accuracy may be obtained with such tools as metallic linen tape and templates.

In many cases the assembly methods used determines the components' placement without any previous proper marking out of dimensions. This will normally be found where a non load-bearing component is placed on top of or inbetween already placed building parts, or where the assembly detail in question must fulfil special functional requirements.

Thus, for example, windows, in many cases, will be installed without actual marking out of dimensions but so that the joints at both sides of the window will be equal. Likewise, wall components of light concrete will often be placed with butt (contact) joints against the ceiling and wall.

A—3 **Measuring methods and—tools**—Measuring tools always contain a certain inaccuracy, and even with skilled use, additional inaccuracies may be expected in operation.

As a general rule, the total inaccuracies of measuring methods and tools shall be substantially smaller than the allowed tolerance for the dimensions to be marked out or controlled.

Marking out and control of dimensions on the building site and control of incoming material (delivered components) will often be undertaken with different sets of measuring tools. In these cases, there is a supplementary demand that there must be good mutual agreement between the different types of sets and tools.

In practice this can be obtained, for example, by having the building foreman keep a set of measuring tools, to which all other tools must be compared before they are approved for use. The building foreman's set shall be used only for such comparisions, which should be undertaken according to an established routine.

Regardless of the type of the measuring methods and tools, inaccuracies will accumulate, when, for example, several measurements are layed out individually in continuation of each other. Therefore, such sequences of measurements should be layed out with a tool that is long enough to cover the total resulting measurement at one time.

As a reference, the following list is a summary of some important tools used for measuring and marking. They can all be used in the production of buildings and building components, but it is vital that the right tool be chosen for each specific job.

	NAME	NORMAL USE
Measuring	**Folding Scale**	Generally for length, height, and diagonal measurements.
	Gauge	Control of small inside and outside measurements.
	Metallic linen tape	Generally for length, height and diagonal measurements.
	Measuring wedges	For example joint widths.
	Modular measuring rods	Height measurements. Marking of fixed points in the vertical plane.
	Pocket steel tape	Generally for length, height and diagonal measurements.
	Steel tape	Generally for length and height measurements.
	Tacheometer	Optical measuring of length in the horizontal plane.
	Taper gauges	Control of hole size and joint widths.
	Template	Marking out of frequently occuring small measurements.
Establishing directions	**Angle prism**	Control of right angles in the horizontal plane.
	Leveling instrument	Measurement of heights.
	Plumb bob	Establishing the vertical direction.
	Spirit level	Control of horizontal and vertical planes.
	Straight-edge	Control of deviations from a straight line.
	String	Establishing a straight line between two points.
	Theodolite	Measuring of angles between vertical planes.
	Water height-indicator	Establishment of identical planes. Marking out of height measurements.
Marking	**Chalk (chalk line)**	Points and lines (on smooth surfaces)
	Marking label	Height distances.
	Nail	Points.
	Pencil	Points & lines (not on rough surfaces)
	Steel reference plate	Height distances. Level fixed points.
	Steel stylus	Points and lines.

APPENDIX B

MODIFICATIONS REQUIRED IN THE APPLICATION OF THE 'ADDITIONAL PRINCIPLE'

B—1 General — Application of the additional principle may give rise to unreasonably small part tolerances or unreasonably large sum tolerances. In this case the principle may be modified by the introduction of more sets of tolerances (complementary tolerances) which in different ways influence the same dimension. When complementary tolerances are applied, the individual requirements may be reduced, but on the other hand it is necessary to check stepwise whether th individual tolerances are fulfilled.

B—2 Possible adjustments — If a component is to be joined to other components through joints the size of which may vary within specified limits, it is natural to make an adjustment of the positioning of the component in accordance with its work size and the size of the joint.

For a certain magnitude of the joint tolerance this makes it possible to allot a larger work tolerance or positional tolerance to the component than that which would have been permitted according to the additional principle. Complementary tolerances should be adopted to each other in such a manner that the requirements as to accuracy represented by each set of tolerances are not automatically fulfilled through any other set of tolerances, and furthermore, in such a manner that all requirements may be fulfilled by means of adjustment which does not interfere with completed work process.

When choosing tolerance for sum dimensions and the corresponding part dimensions, the tolerances may be specified in such a manner that the probability of an unacceptable combination of part deviations will be represented by a suitably small known figure. However, this presupposes that the statistical distribution of the individual deviations of dimensions is known from current production control, and that combined deviations are statistically interdependent.

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