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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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DEFINING FUNCTIONAL REQUIREMENTS ON BUILDING MATERIALS[1/]

by

TARJA CRONBERG

PERSTORP AB
Perstorp, Sweden

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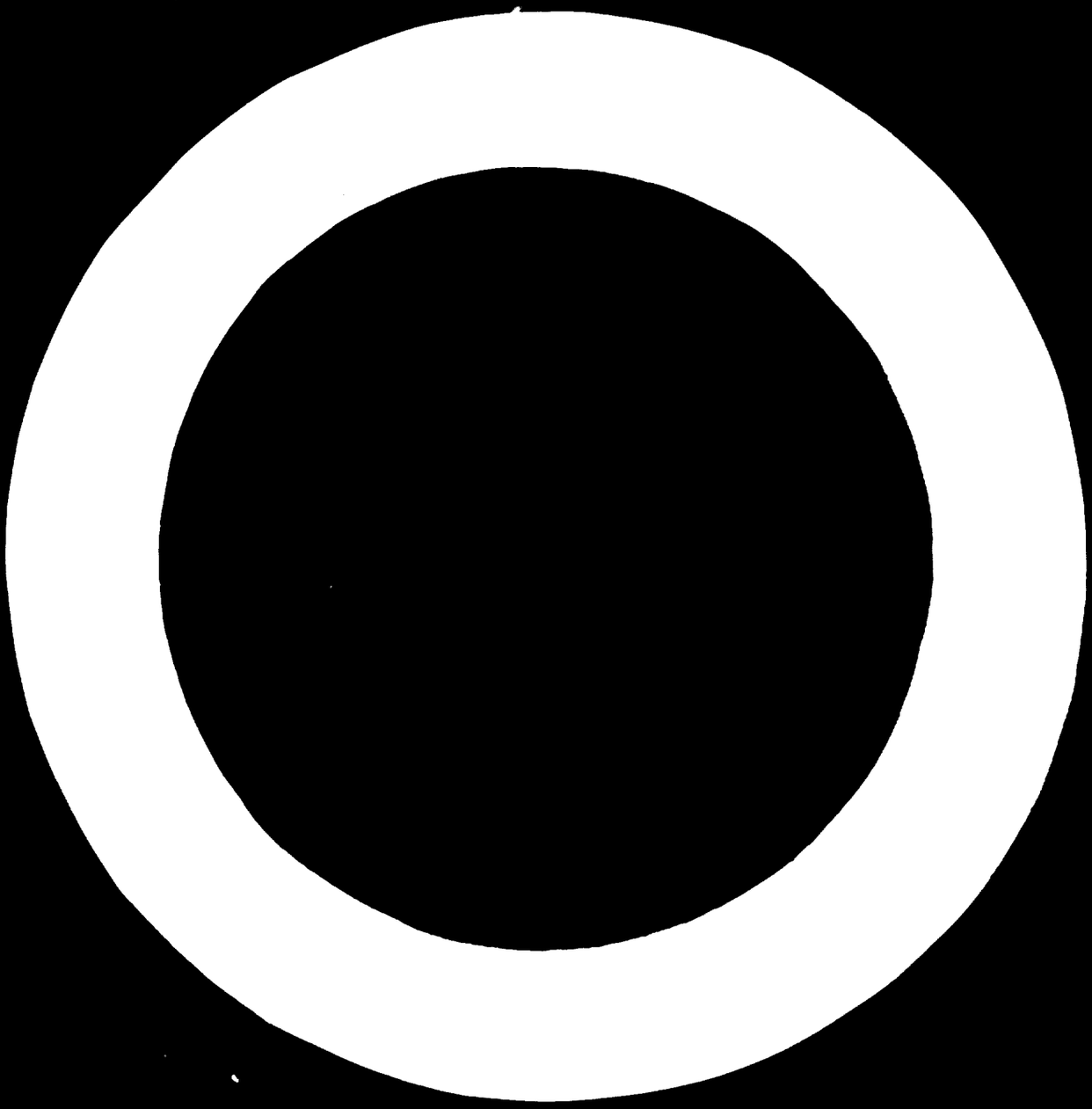

SUMMARY

Functional requirements on housing hardware: building elements, components and materials are defined as the requirements which are derived from the human needs and the corresponding human requirements on buildings.

These requirements which are qualitative in nature and which can be defined on various levels in the building system are discussed in relation to properties and other requirements.

As the basis for functional requirements are human needs and human requirements on buildings methods for studying these are discussed, a model is suggested for a procedure for deriving functional requirements on housing hardware from these needs. The implications for building materials are considered. The consequences of this approach are commented upon in relation to the development of new solutions, especially for the developing countries and for the application of new materials.

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1. INTRODUCTION

The erection of a building has one aim - to satisfy the requirements the user has on his built environment.

This fact has now been rediscovered, having been lost for the past years, as it was of minor importance when traditional design solutions and materials were used, of which both the builder and the user had sufficient experience, as they were results of a long evolution.

The reasons for this rediscovery are several:

- the urbanization process has created new types of built environments where human requirements have not been satisfactorily dealt with
- the appearance of new products and materials on the building market, which are not compatible with existing norms and standards
- the rising costs of traditional building solutions and materials.

Consequently the question of user or human requirements and their application on different levels of the physical environment are being discussed and studied among professional organizations and bodies.

The major research efforts in this field so far originate from the U S A, where the National Bureau of Standards has developed the performance concept to be applied in Operation Breakthrough (1) and from Japan, where the Building Research Institute is developing a systematic approach for the selection of building materials (2). Research work is also being carried out in England and the Scandinavian countries.

Among international organizations CIB (International Council for Building Research Studies and Documentation) has created a new working group (CIBW60) for the application of performance concept and reactivated a working group for the human requirements (CIBW45). In addition to this human requirements were dealt with at the 5th CIB Congress in June 1971 in Paris (3).
In May 1972 RILEM, ASTM and CIB will organize a symposium with the theme "Performance Concept in Building", where human requirements will be one of the topics to be discussed.

With this background the objective of this paper is to outline the possibilities of defining functional requirements on building materials on the basis of human requirements on buildings.

2. FUNCTIONAL REQUIREMENTS

2.1 Definition (functional or human requirements)

The requirements to housing hardware: building elements, components and materials, which are derived from the human needs and the corresponding human requirements on buildings are called functional requirements.

Characteristic to these requirements is that

- they are oriented to the use of the building and to the user
- they are independent of the technical solutions and materials used.

2.2 Functional requirements on different performance levels in the building

Functional requirements can be defined on different levels of performance in the building system: building, building element, component, material and are characterized on corresponding level by properties relevant to function to be performed. Functional requirements are formulated in a different way depending on the level in question but reference should be made to a functional requirement on the level above and on the building level to the human requirement in question. This is necessary in order to foresee the consequences of the requirements to the total building solution and its characteristics in use.

2.3 Functional requirements vs properties

When functional requirements are transferred to properties of the material or object two conditions should be met:

- the property or combination of properties should be relevant and sufficient to cover the various aspects of the functional requirement
- one should be able to quantify the properties and evaluate them with accessible methods.

The difficulties encountered in order to meet the first condition are evident when studying material and product specifications in the building field. The properties usually specified can be referred to three categories:

- properties which can be directly associated to product attributes
- properties which can be measured by numerical methods
- properties of which the builder and producer have experience

In most cases no reference is made to the functions to be performed or to requirements on higher system levels (building elements, building).

Although functional requirements are qualitative in nature (the corresponding quantified requirements are often called performance requirements) one should when applying functional requirements be able to quantify the requirement and refer to an evaluation technique for assessment. Even if this is possible for some of the chosen properties, which consequently can be assessed in the final solution we still lack knowledge of how to quantify other properties especially those concerning functional requirements corresponding to human requirements from psychological and sociological needs. The problem of comparing quantitative and qualitative properties is therefore one of the most serious ones associated to the second condition.
Another problem associated to evaluation is the measurement of the combined effect of the relevant properties in the environment, in which the product is to be used.

2.4 Functional requirements vs other requirements

In spite of the problems mentioned under 2.3 to be solved when making functional requirements operative in planning there are several reasons for the continued development and use of these requirements:

1. Material dependent requirements and standards slow down the development of new alternatives and are an obstacle for innovation in building.

2. The use of functional requirements will allow for evaluation and comparison of technical alternatives on equal basis independent of the specific properties of the material.

3. Functional requirements present a link between the user and the building industry, thus improving possibilities for communication.

4. Priority can never be stated only between material properties without regard to the functional requirements.

5. The use of functional requirements in spite of the problems remaining to be solved will increase our conciousness of these requirements and lead research and development to study the less familiar human requirements and corresponding functional requirements on housing hardware.

3. METHODS FOR STUDYING HUMAN REQUIREMENTS

In the past the human or user's requirements have mostly been satisfied through the designer's intuition or by studying existing solutions which appeared satisfactory. Because of this research and development has been mostly occupied with evaluation techniques and standards for the latter case and the human requirements have not been systematically identified.

For the systematic identification of human requirements two methods have been suggested (1):

1. Systematic analysis of existing housing solutions and abstraction of human requirements from these.

2. Study of human needs and user characteristics.

An example of the first approach is the list of human requirements presented at the CIB Congress in Paris this year (3). The list was created as a result of a large survey among CIB members and other professional organizations and presents a review of human requirements, which are stated to be universal. No reference is consequently made to the users' physiological, psychological and social needs or users' characteristics.

The following kinds of requirements are listed (3):

- acoustical
- olfactory and respiratory
- tactile
- visual (lightning, quality of what is seen in the interior, view of the outside world)
- thermal and humidity
- requirements related to moments, vibrations and deformations of buildings
- requirements relating to magnetic field, to electric field, to ions and ionizing radiations
- insulation
- safety (stability, safety at fittings, in case of fire, with regard to intrusion, of movements within the building)
- hygien, purity of air, removal of used water and materials, alimentary hygien, bodily hygien etc
- privacy: in relation to the outside and in relation to the members of the group
- adaptation to the method of occupation or use of the premises
- requirements for the case of disaster
- (economic requirement, aesthetic requirement).

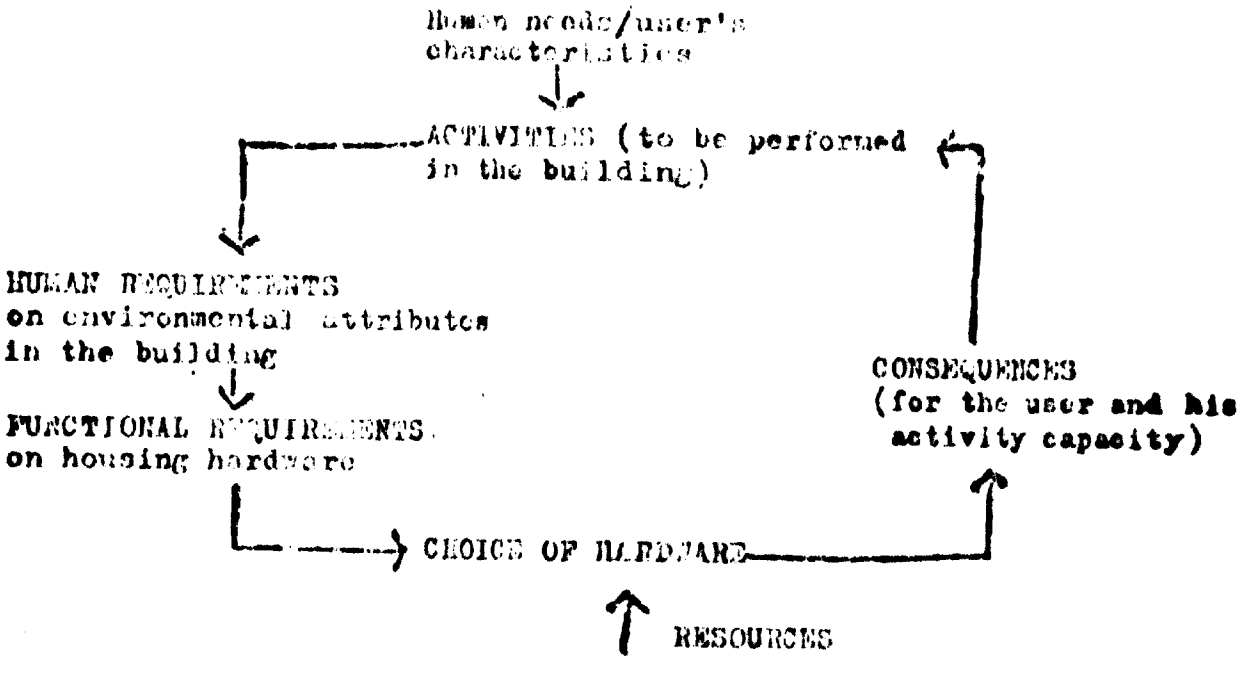
The second approach is more diffical' and will not today give as concrete result as the first one. The application will require detailed knowledge of human needs (physiological, psychological, social), the specification of users' characteristics (age, social group etc) and evaluation techniques have to be developed to measure the "needs satisfaction".

However, when successful, this approach will provide for innovation and be free of traditional housing solutions. Because of this, the method should be especially considered when searching for solutions to be applied in countries where the human requirements, both qualitative and quantitative, might be quite different from those abstracted from the existing solutions developed in industrialized countries, depending on the user being on another level of need satisfaction and different users' characteristics.

This approach is developed in the following to discuss its implications for functional requirements for housing hardware including building materials.

4. A MODEL FOR DEFINING FUNCTIONAL REQUIREMENTS ON HOUSING HARDWARE

In order to describe the relations between different stages in the process of defining functional requirements the following model is presented and discussed:



4.1 Human needs/user's characteristics

Human requirements are basicly derived from human needs and analysed in relation to user's characteristics (age, social group, economic resources etc). As human needs are today not empirically accessible depending as well on insufficient knowledge of how the human needs are reflected in the built environment as on the lack of evaluation techniques, the step from needs directly to requirements on buildings is too long.

Human needs are commonly understood to be the driving force for human behaviour, which on the other hand is composed of activity elements. It is therefore suggested that human activities are studied as a link between needs and requirements. This is motivated as our knowledge of activities is more advanced than that of human needs and research results and evaluation techniques for activity analysis already existing within various disciplines.

4.2 Analysis of user's (or human) activities

Examples of the application of activity analysis as a basis for building design exist. However, the choice of activities has as a rule been limited to traditional, well-known activities for housing to such as to sleep, to work, to play, to prepare food, to eat, to entertain, to store, to clean and to pass in/out.

Because of this only the so-called basic human requirements have been treated and the analysis of other activities and human requirements has been neglected.

It is therefore important that when making up activity lists for housing in countries where the cultural and social background differs from ours that the list of traditional household activities is not transferred to these conditions without a deeper analysis of other activities of importance to the user. From where establishing a list of activities to be performed in the built environment the choice of activities is decisive. This can be done through interviews of the user or user groups, through direct observation of the user's way of life and activities by studying user's characteristics and applying the existing knowledge on activities. In order to get the best results all of these methods may be used simultaneously.

Activities with social and psychological origin should not be omitted. As examples of this type of activities are given: to learn, to participate, to identify, to orientate, to seek contact, privacy, to rest, to get old etc.

The list of activities should also possible be structured in relation to the user characteristics, when this knowledge is available.

4.3 Human requirements on environmental attributes

Having established the list of activities, which the built environment should allow to be performed, structured in relation to the characteristics of the various user groups, each activity is studied with regard to the necessary or desirable environmental attributes for buildings and requirements on these.

Spatial characteristics is the only environmental attribute that so far has been studied in any detail as a function of user activities. This approach is extended to all other attributes as well and to the "new" activities of psychological and social origin.

In spite of the actual lack of knowledge of how the user's activities are reflected in the built environment, this analysis will increase our consciousness of these problems and help to solve them.

It is suggested that the human requirements on the various environmental attributes (or physical parameters) in buildings such as interior climate, spatial characteristics, structural considerations, appearance and equipment (sanitary, food preparation, storage etc) are considered from four different aspects:

1. Requirements of accessibility/usability refer to the easy and comfortable access to the attributes and its qualities necessary or desirable for the use of the building or its parts when performing the activity.

2. Requirements of safety/protection refer to the qualities of the attributes concerned to the degree of safety with regard to injury and other risk factors for the health and wellbeing of the occupant as well as the protection of his property.

3. Requirements of perception/comfort refer to the user's reaction (both psychological and physiological) on the built environment, his structuring of the information in it and the ability to orientate and identify himself.

4. Requirements of social accessibility refer to the occupant's need for contact or privacy when the activities are taking place.

Durability or the possibilities of controlling or regulating the qualities of the attributes as a function of time are not taken up as a separate aspect to the requirements but should be implicitly stated in each requirement (especially accessibility/usability).

Examples of the questions to be dealt with for the four types of requirements on the attributes when analysing the activities are given in the appendix.

After a separate treatment of each activity for its requirements on the environment and the environmental attributes, the requirements corresponding to each other will be studied to see for which requirements it is sufficient to state one general condition, same for all activities, (for example the allowed content of noxious gases in the air) and which of the requirements will be activity dependent (for example the requirement of vision). When the requirements of two activities are incompatible (for example acoustical privacy and acoustical contact) the following questions should be asked:
When and for how long are the activities to be performed?
Where are the activities to be performed?
If the requirements cannot be brought to agreement on the time or space dimensions, priority should be stated to one or the other of the activities in relation to its importance for the user.

4.4 Functional requirements on housing hardware

The output of the previous stage is a set of general requirements on the environmental attributes, which are the same for all activities (especially the safety/protection requriements are of this type), and a set of requirements which are dependent on the activities to be performed in the building.

These requirements refer to the environmental attributes of the building as a whole. Since these attributes — also called the physical parameters of the building — are not equal, exception is made for some of the structural characteristics, with the systems of housing hardware, the human requirements on the attributes have to be transferred to functional requirements on hardware. As this transfer procedure means a change of performance level, from the total building system to its subsystems; elements, components and materials, it may even mean a reformulation of the requirement in terms characteristic for the latter levels. Thus for example requirements of acoustical privacy will in the building level be defined in terms of noise level, on the material level in terms of sound transmission of the materials involved. However, reference should always be made to original requirement for later identification.

The transfer of the human requirement to hardware should always be done to a "functional system", that is to all the parts which influence the satisfaction of the requirement. Thus for example the requirement of a specific room temperature should be considered for the functional system composed of building elements, openings (doors, windows) and heating or cooling systems together. When considering the separate requirement for each of these, reference should be made to requirements on the others. The transfer directly to a building element or a material should only be made when this subsystem alone influences the satisfaction of the requirement or when the requirement has to be satisfied by all subsystems equally.

Functional requirements on building materials will be of two types:

1) Requirements derived from those requirements on environmental attributes, which can be satisfied by material properties alone, without regard to the technical solution where the material is to be used.

2) By studying the implications of those requirements on environmental attributes which in the first stage are transferred to functional requirements on elements and components, on the properties of the materials used.

In the first case the expected performance can be accessed by material properties alone, in the latter case the performance must be evaluated also for the elements and components in question.

In the following examples are given on the basis of the types of requirements discussed in the appendix for both of these cases.

1. Functional requirements on material from human requirements on environmental attributes in building.

Examples:

Environmental attribute	Functional requirements on materials concerning:
Climate	
- humidity	permeability
- contamination	"
- reverbation time	sound reflexion
- radiation	emission of radiation
- noxious gases	" " gases
- dust	" " dusts
- odours	" " odours
Structural characteristics	
- fire	combustibility fire retardance
Appearance	
- colour	colour
- touch	surface characteristics

2. Functional requirements on building materials implied in functional requirements on building elements and components

Environmental attribute	Functional requirement on materials concerning
Climate	
- temperature	Heat reflexion and transmission,
- acoustics	Sound reflexion and transmission,
- vision	Light reflexion and transmission
Spatial characteristics	
- dimensions	Strength
Structural characteristics	
- failure	Strength
- vibrations	"
- movements	Dimensional stability,
- intrusion	Strength, chemical composition
Appearance:	
- form	Strength, mouldability

As has been stated before the choice of relevant and sufficient material properties to satisfy the functional requirements is difficult and development work is needed both for the formulation of the functional requirements in an operative way and for the study of corresponding properties. To what extent the functional requirements or materials can be quantified depends on whether or not we have been able to quantify the human requirements on the environmental attributes. The situation today is reviewed in (5). This knowledge has then to be combined with the knowledge of the environmental conditions on site for a quantitative statement.

4.5 Choice of housing hardware

Choice of the housing hardware will be based on
- the functional requirements defined in the previous stage
- the resources available (economic, technical, personal)

When the choice is made among existing technical alternatives the functional requirements on building elements and materials are compared with the properties of the available solutions. The renouncement of any of the functional requirements as a result of a cost/benefit analysis should be done not only by comparing the functional requirements on hardware but also by comparing the human requirements and the human activities affected by the choice.

When developing new solutions the functional requirements should form the basis for the choice of materials, components and elements.

4.6 Consequences

The feed back of the model, the effectiveness by which the functional requirements have been stated in planning and met in the actual solution, is measured as the user's capacity to perform necessary and desirable activities in the built environment, with consequences for the satisfaction of his physiological, psychological and social needs.

5. CONCLUSIONS

In spite of problems remaining to be solved in the development of functional requirements as a basis for the design of buildings before the requirements will be operative in use, the expected advantages of this approach when compared with the traditional, not function but material dependent requirements and codes should motivate a continued development.

1. Consequences for the development of new housing solutions

The development of new housing solutions by using user's characteristics and the activities to be performed in the building as the basis of the human requirements on environmental attributes and the corresponding functional requirements on hardware is of special importance when searching for solutions to be applied in the developing countries.

1) The solutions will be adapted to the way of life and the social and cultural background of the user. Thus the acceptance and the appropriate use of the new environment by the user will be easier to obtain. As a house is not just a human shelter, but a product which can fulfil many other physiological, psychological and social functions, it is not sufficient to transfer the experience from the industrial countries and to modify only for the differing environmental conditions.

2) The allocation of resources carried out in relation to functional requirements will be rational and equal or better quality of dwellings will be obtained from the user's point of view.
This is especially important when supplying space or equipment for the users' activities, but may even apply when allocating resources for acoustical properties, appearance etc.

2. Consequences for the application of new materials

The reformulation of building regulations in terms of functional requirements on building products and materials instead of specifying materials will make the process of introducing new materials on the market less time consuming as the equal evaluation of alternatives satisfying the same function will be possible.

Research of development work will orientate to study material properties which are important for the fulfilment of the functional requirements and the evaluation of them in a way relevant to the function and not to the material.

When allocating resources the relation of functional requirements to the human requirements will provide for a rational choice of materials and properties in respect to the use of the building.

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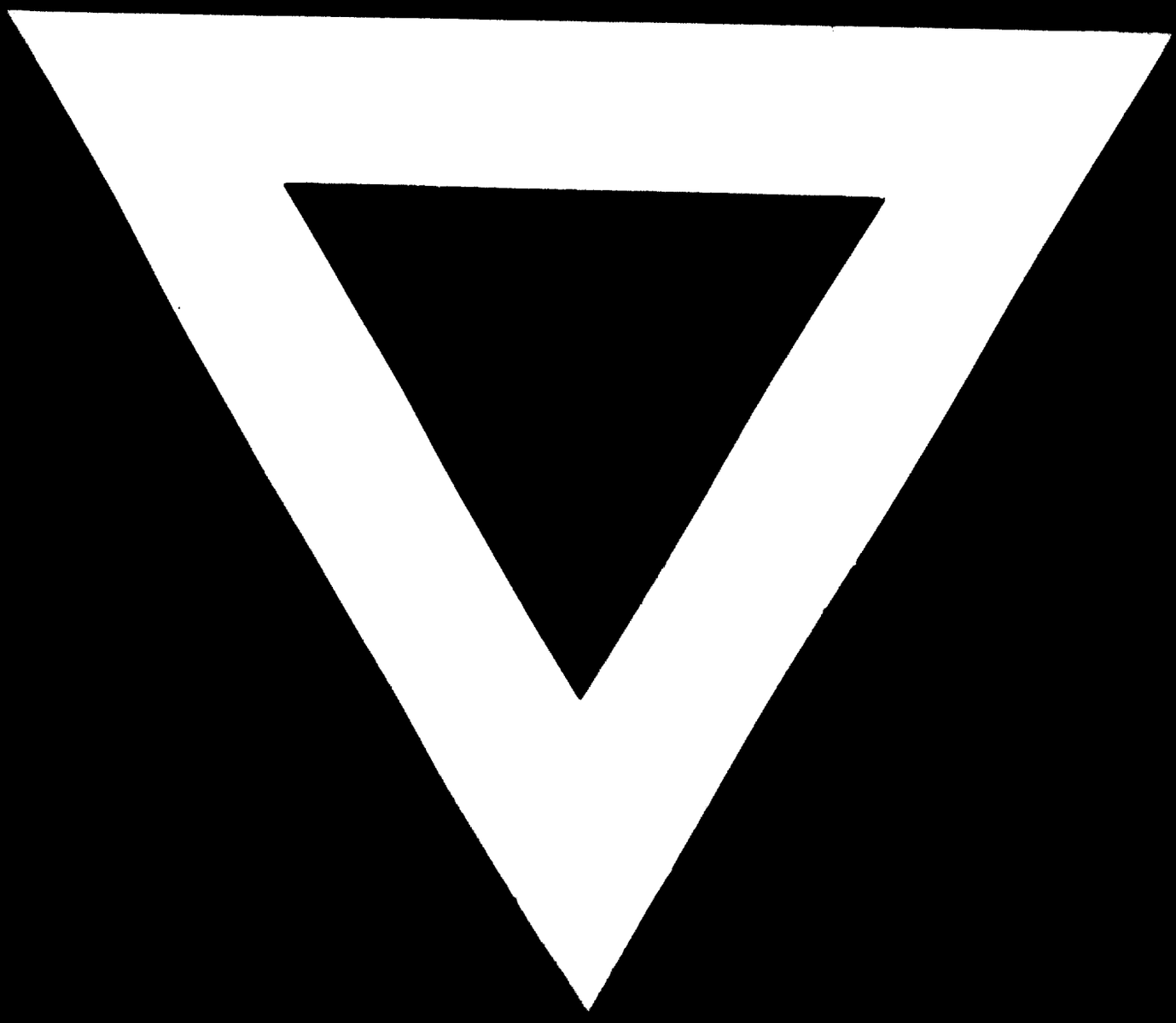
APPENDIX: EXAMPLES OF VARIOUS ASPECTS ON REQUIREMENTS TO BE CONSIDERED FOR EACH ACTIVITY IN RELATION TO ENVIRONMENTAL ATTRIBUTES

Environmental attributes / Requirements	Climate	Spatial characteristics	Structure/ characterics	Appearance	Equipment
Accessibility/ useability	Air -temperature -humidity -movements -contamination Vision -luminance -contrasts -spectrum Acoustics -noise level -impact noise -reverbation	Spatial -dimensions -relations -connections	(Safety/protection) (Perception/ comfort)	(Perception/ comfort)	Access to location Antropometrical design Method of operation Regulation (perception/comfort)
Safety/protection	Radiation Noxious gases Dusts	Circulation within and in/out of the building	Structural failure Fire Intrusions -people -animals	Identification of danger/risks	Injuries to people/ damage to structure due to -installation -operation (electrical sparks, explosions, hot surfaces) -storage (radiation, gases etc)
Perception/comfort	Vision of: -interior -outside world odours Hearing: -noise -reverbation	Dimensions Proportions Identification Orientation	Discomfort due to: - movements - vibrations	Colour Form Touch Symbolic values Identification Orientation	Identification of -location -function Discomfort due to operati - noise - vibration
Social adaptability (contact/privacy)	Visual contact/ privacy Acoustical contact/ privacy	Space, spatial relations and connections for easy access to contact/ privacy		(Perception/ comfort)	(Accessibility/usability



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