ARCHIMETRICS: A NECESSARY DISCIPLINE FOR OBTAINING OBJECTIVE VALUES FROM ARCHITECTURAL SUBJECTIVE VALUES

SOMEN CHAKRABORTY
Professor, Department of Architecture, Jadavpur University, Kolkata 700032 ,INDIA
somen_c@eudoramail.com

Abstract. If we are serious about using CAAD then many subjective design steps normally performed by the architect apparently creatively using subjective values are to be performed by the computer. To fulfil this purpose a tremendous research work is necessary to transform subjective design methods and values to objective design methods and values which should give realistic design solutions not less efficient than that produced by human being. For this purpose it has become imperative now to develop new methods or borrow methods from other disciplines like statistics and psychometrics so that this kind of transformation can be done effectively. It appears that this may form a distinct discipline by itself which may be termed as *"archimetrics"* keeping parity with similar terms like psychometrics, econometrics, anthropometrics etc. With this view in mind the author has attempted to develop few methods and concepts by virtue of which some of the subjective design methods and values can be transformed into objective design methods and values. The author describes here some basic concepts required for this purpose

1. Introduction

All descriptions of an architectural situation, which when studied rigorously, can be represented subjectively with qualitative values or objectively with quantitative values. For example, we can describe an architectural situation by saying that "this corner place is very much attractive" or "this stair-case is not convenient for going up". These are subjective description of architectural situations with qualitative values. If we say that "this stair flight has 10 risers of height 175 mm each with width of tread as 250 mm" or 'this room has ambient temperature of 27 deg centigrade now" we are actually describing the architectural situation objectively by quantitative values.

For this reason architectural decision processes also fall under two categories – (i) *subjective*: which primarily deals with situations that can be normally described by subjective values and which require intuitive or creative approach for decision making and (ii) *objective*: which deals with situations that can be described by objective values and which may be analysed using numerical values for decision making. In general we find both types in combination.

Because of the complexity of architectural problems, most of the characteristics cannot be represented quantitatively. Therefore, many significant parts of architectural actions, decisions and design processes are also not analytical in nature. As a result, in absence of quantitative representation of architectural characteristics, and also in absence of analytical design processes we cannot justify many architectural decisions unambiguously, reasonably and convincingly. This state of affairs is not desirable when we have now with us many advanced mathematical tools and computers

There are two reasons why we cannot deal with the architectural problems analytically. (a) In many cases description of architectural characteristics are so much subjective that normally we cannot represent them numerically and process them analytically. (b) Even if we can represent some characteristics numerically and can process them analytically the variables in any small case are so numerous that the mathematical representation of an architectural situation becomes very much complex and analysis of the description becomes extremely cumbersome and time consuming. In connection with the first reason we can say, in general for any discipline, that if the knowledge about any situation or phenomenon is made more and more accurate through rigorous investigations and research our ability to comprehend the situation quantitatively and analytically is increased more and more. This is also very much valid for architectural problems. Regarding second reason, however, we can say that with the advancement of capabilities of computers our capabilities of fast calculations have increased so much that we need not normally bother about time consumed for analytical calculations. Our present day botheration, in fact, should be how to quantify architectural characteristics and how to make architectural design processes analytical which are normally considered as subjective matters.

Today, therefore, we can envisage a day in future when many architectural characteristics, at present considered subjective, may be represented by numerical values and replace subjective design process by analytical procedures. A discipline which can advance our architectural knowledge towards this may be termed as '*archimetrics*' – a discipline of architectural measurements - keeping parity with similar terms like psychometrics, econometrics, anthropometrics etc For this purpose it has become imperative now to develop new methods or borrow methods, if suitable, from other disciplines like statistics or psychometrics so that this kind of transformation from subjective values to objective values in architecture can be done effectively.

2. Characteristics of Description of an Architectural Situation

We can look at the term "architecture" either as a *discipline* or as a *physical entity*. When we think of architecture as a discipline it can be defined as "*the art and science of building design and particularly the design of any structure for human use or habitation. Architecture, further, is the art of applying human values and aesthetic principles to the science and technology of building methods, materials and engineering systems, required to comprise a total building project with a coherent and comprehensive unity of structure and site*."(New Jersey State Statute, Title 45, Chapter 3, Clause 1.1). Architecture as a physical entity "*is a built-environment (or a structure – a physical entity) meant for human use or habitation"*.

When we intend to describe the physical entity of an architectural situation we can do it successfully and completely by objective values like various dimensions, relative location of different parts, specification of materials used for different parts, physical environmental conditions, etc. But if we want to represent certain important attributes of the built-form we are required to use either objective measure if the effect of the built-form is physical (like area, volume, weight, cost, stresses on building materials, heat gain, air flow within a room, etc) or subjective rating if the effect of the built-form is on the perception of users or on-lookers (like speciousness, sense of security, convenience to work, comfort, aesthetic experience, etc.).

In all cases we are concerned with the effect of built-form related to certain attributes of architecture where built-form is a physical entity that can be described totally by objective measure and the effect may have either a subjective rating or an objective value (Radford, A. D. and Gero, J. S.: 1988). Problem arises when effect of the built form for a particular attribute is subjective. Resolving this problem of psycho-physical relationship into a mathematical relationship by properly converting psychological rating to numerical values selecting proper scale in architecture is one of the objectives of archimetrics. Well known two examples are illumination level and loudness level which are subjective attributes dependent on values of built-environment but converted to numerical measures for the sake of objective manipulations.

3. Analytic Design Process

Satisfying all known constraints architects are required to propose an Architectural situation (an acceptable *design* which is called *feasible solution* in the optimization literature) optimizing over different criteria. Difficulties of arriving at the architectural design solution using analytic approach can be divided into three broad categories: (i) Many important criteria, like aesthetic quality, functional values, etc., are subjective in nature. (ii) Moreover, how over-all value of a design is obtainable (evaluation) from different values of criteria is also not known and appears to be extremely complex from the point of view of numeric representation. (iii) It is also not known how a representation of a built-form satisfying all constraints can be transformed from representation of another satisfying built-form so that some potential feasible solutions can be scanned over easily for evaluation. Because of these three reasons we normally resort to subjective approach for arriving at a design solution for a given architectural problem.

But through thorough study and research work we can understand the characteristics of constraints, find the values of criteria for different designs, combine values of all criteria and develop the process of generation of different potential built-form. For this purpose a significant part of research work will involve converting physical description of built-form to objective values of it, converting subjective rating of different criteria to objective values and analyzing numerical values representing subjective criteria to arrive at a design solution. Knowledge of doing this will also form a

4. Concept of Law of Large Numbers

In the subject of probability “law of large numbers” is an important concept. In the mathematical probability this law can be mathematically derived based on certain axioms. These axioms, in fact, are nothing but the result of the law of large numbers if you consider this as the basic law. This law is found true (empirically) in the real world. But, as we know, for the benefit of sanctity of independence of mathematics mathematical probability is developed based on axiomatic approach.

But for the purpose of us, who deal with the real world, this law can be taken as a basic law applicable in the real world. Before stating the law let us assume that the laws of nature (excluding the elementary particle level) are such that to every effect there is a fixed cause. As a result we can say that under a given set of physical conditions the out come of any phenomenon must be fixed. There can be a variation in the outcome provided there is a variation in the given set of conditions. But in practice we cannot control the conditions fully for any experiment or phenomenon (say “event”). More we control the conditions less will be the variation in outcomes of an event. Theoretically, full control of conditions will give same outcome of the event though we may conduct the trial as many times as we like. But in practice this type of control is not possible. Moreover, we my encounter a situation for which we have to gather knowledge where such control is not valid and we get varieties of outcome. It is observed in reality that if we control the conditions as much as we can and leave the variation of conditions beyond our control depending upon natural fluctuation then the variation in outcome will be found stabilized as we go on increasing the number of observations. Theoretically, for infinite number of observations with this condition, the distribution of different outcomes fully stabilizes (i.e. become fixed). This is, in fact, the Law of Large Numbers stated empirically. Applications of entire probability theory and statistical methods are dependent on this fact. In practice if we consider large number of observations (within practical limit) on a phenomenon at several occasions the variation in outcome for these occasions will not be significant and can be used for our practical decision making. For instance if we are supposed to design a housing complex we may not know who will actually occupy the units in future. But we may assume certain characteristics of the prospective clients belonging to the target group depending upon our survey on the target group. Because of the law of large numbers the proportion of varieties of choices of the target group will remain fixed under a given set of conditions. This is a powerful tool which is used in statistical methods and will form a basic tool for archimetrics.

5. Concept of Random Variable

The outcome of an event may be viewed in varieties of ways depending upon on which the investigator is interested. If a particular paint is applied on an external wall we may be interested in (i) attractiveness of the paint, (ii) durability of the paint, (iii) preventive capacity for water seepage, etc. Here, application of paint is an event and several items of interest represents several characteristics or attributes. Each of the characteristics or attributes can have varying values with distribution to become stabile in the long run as per law of large numbers. But value of a particular attribute for a given event cannot be predicted with certainty. As stated earlier, however, the distribution of aggregate of values of an attribute of all outcomes can be predicted. In other words the value of an attribute of a particular outcome can be predicted with probability. If outcome of any characteristics or attribute can be represented as a numerical value then the characteristics or attribute is called a “random variable” whose value will vary randomly from event to event. But these values will have a stable distribution for large number of events. For a given event the value can be predicted with probability. For a given experiment or phenomenon we may be interested in varieties of random variables.

In architecture in a high rise housing project there may be a variation in the choice of floor level where the unit is situated, or for given outline of floor plan different possible floor plans may be differently evaluated by different prospective purchasers. Here purchasers choice is considered as random outcome as purchasers are randomly selected from a target group and their choice is a random variable which can take varieties of values. But the beauty of the random variable is that for large number of purchasers the distribution of choice will automatically stabilize which will approximately match with the findings of a sample survey allowing architect to make decisions regarding selection of design in a predictable way.

6. When Archimetrics can be used

To convert subjective values to objective one meaningfully we must have subjective rating of an architectural situation by many subjects (users or clients or on-lookers, etc.). If many subjects give their subjective judgments (may be in the form of yes/no or with different qualifying categories like very bad, bad, cannot comment, good, very good, etc) on a particular architectural situation then their opinion can be numerically transformed and can be applied in general situation. It is, however, necessary that the opinion about the situation be taken from the subjects who should belong to a target group for whom the evaluation will be applied eventually. We must remember that for a given architectural situation different opinion may be given by different people. But as we want to carry out time consuming and costly research work not to satisfy only one or few subjects but to satisfy some group of users who may be the target group for an architectural project we have to accept the variation within the target group. Therefore, results obtainable by archimetrics are normally meant for a viable target group which comprises large number of users for an architectural project or for few users who are unknown to the architect but may come from a known large target group randomly.

6.1. A SPECIFIC EXAMPLE: HOUSING UNIT UNDER MASS HOUSING

When we talk about the preparation of a mass housing scheme, in addition to the constraints like site conditions and its environs, budget, etc we must also know the characteristics of the target group for whom the plans are to be prepared. Normally these groups are selected by the organizers of a cooperative housing society matching with their criteria or by a promoter offering certain facilities within a given budget or by the Government agencies backed by political decisions. There may be different type of clusters, normally depending upon the cost of each housing unit, within a housing scheme. If clusters are based on cost of units then, normally, all housing units within a given cluster have almost same area. My problem here is to select the best plan out of many given plans with the same outline of area by numeric evaluation.

6.2. STANDARD USER REPRESENTS AVERAGE OF USERS.

Normally at the time of preparing the plan each individual households are not known but their general characteristics are known. There may be variation in household income, social background, attitude towards living style, number of family members, age and sex composition, etc all of which may contribute towards evaluation of a given plan. But architects are to design and select the plan under these obvious variations satisfying an average user (imaginary) called "*Standard User*" (Chakraborty, 2003) who can be considered as representative of the target group and whose satisfaction is taken as average satisfaction of the target group. It is assumed that if the standard user is satisfied then the target group is satisfied. Then the question is how to find out different satisfaction values for this *standard user* representing a given user group and how much reliable it can be?

6.3. FINDING SATISFACTION VALUES OF AVERAGE USERS

There can be different ways of finding satisfaction values of users, which is subjective in nature, for different design provisions in a unit starting from location of a tower-bolt of a door or window to the entire design of the housing unit.

6.3.1. Ask users to Evaluate

We can select alternative designs for any part of a house and ask users (who have practical experience of using such design situations) to evaluate the designs with relative values. We can take many evaluations from many users falling under the target group. But there will be two problems: (a) Users can rank the alternative designs but cannot assign any absolute values. Even if they put absolute values there may not be any rationale – we can only take the relative ranking. (b) Ranks given by different users for a set of alternative designs may vary. (c) Users may not have experience with all alternatives posed to them for evaluation. Therefore, we must take values from users who have experience on at least two alternative designs. Then only we can place one design relative to another.

Once the data on ranking of different alternative design solutions are collected (even if for some users it may be incomplete) we can find an average ranking of all alternatives using statistical method. Subsequently it can be fitted on a theoretical curve (like sigmoid curve) to get absolute values of each alternative designs.

6.3.2. Ask Architects to evaluate

Architects (i) who have got experience in designing houses, (ii) know the clients' mind very well, and (iii) are not egoist or biased can be asked to put values to different solutions of a problem. Their past experience can be considered as average of samples on which he experienced. If we investigate several architects and get their relative ranking then we will be getting a data of several ranks of which each can be considered as an average of samples (subjective) the architect encountered in his practice. These data can again be statistically analyzed based on the similar approach suggested for evaluation by users in the paragraph 6.3.1.

6.3.3. Theoretical Evaluation based on Properties of Actual Design

We can evaluate an architectural situation not by asking users or experts but by theoretically evaluating the quality of the plan from the properties of the part of it for which we have prior knowledge evaluated by any of the methods mentioned above. It is also required find how efficiently parts are combined. However, in this type of theoretical evaluation it is required to verify it with opinion of the users.

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