# Desirability-Based Architectural Design of Forms

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**Abstract.** The forms of built environment are created, developed and detailed by the designer, are evaluated with the rules of science/engineering, and finally are approved by the designer. The decisions and personal preferences of the designer, therefore, are vital for all design stages. Desirability factors, can express clearly and explicitly the views of the designer about the level of desirability of a design object/an aspect of the form under design. The desirability factors are associated with the design (evaluative) models, within the design media, and affect the process of selection among design variants (the results obtained from sole engineering), in the direction favoured by the designer. The examples of the paper, discuss the methods of definition and application of desirability factors to architectural design. The concept can be used for various engineering disciplines involved in architectural design, and can be used within the conventional and digital design media.

**Key words**: desirability factor, digital design, architectural design, design model, design automation

## 1 INTRODUCTION

Design is a major field of research in all design domains, and researchers have produced many papers about theory of design.  Certain of these leading studies may now provide a sound basis for studies in design practice. Figure 1, symbolises the basic components involved in a design process (R Oxman, 2006).

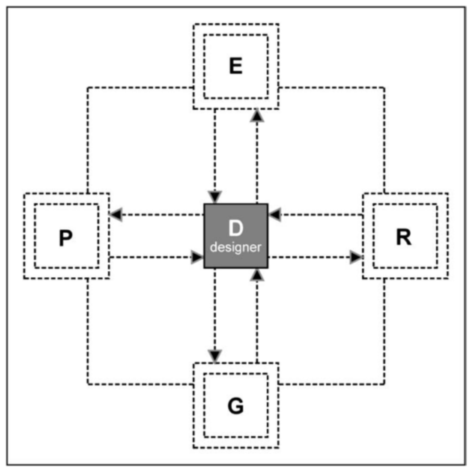


Fig 1 'Generic schema' (for design processes), R Oxman, 2006

The changing nature of design objects and processes with the technological changes, is also studied (R Oxman, 2008). The schema of Fig 1, is general and could be applied to any design domain, here, the Designer has the central role and interacts with all four necessary design components (activities), {R=representation, G=generation, E=evaluation, and P=performance}.

The type of 'interaction' between components varies for different design conditions, such as conventional paper-based design and 'digital design'. The term digital design implies a self contained way of designing exclusively within a computational environment. Oxman defines eight variations of the generic design schema with differing types of links and interactions (between the design components) to incorporate various design conditions. In addition, generally, five types (levels) of models may be required in a design media, among them, the ‘evaluative’ models are used for scientific/engineering evaluation and judgment regarding the form under design.

This paper shows that the personal preferences of the designer may be associated with the evaluative models of an architectural form within the design media by the use of ‘desirability factors’ (M Heristchian 2010). A desirability factor is the most simple and explicit form of ‘desirability data’ regarding an aspect of a form. The desirability data related to a form, in general, could involve hierarchy of desirability factors, and in that case, the term ‘desirability base’ would be more appropriate. The discussions of the paper, however, are given in terms of desirability factors. To explain the matter, consider the following example:

Figure 2, shows an aerial view of a gymnasium in Japan during its construction stage (Tomoe Corporation). The dome belongs to the class of domes that are called scallop domes.

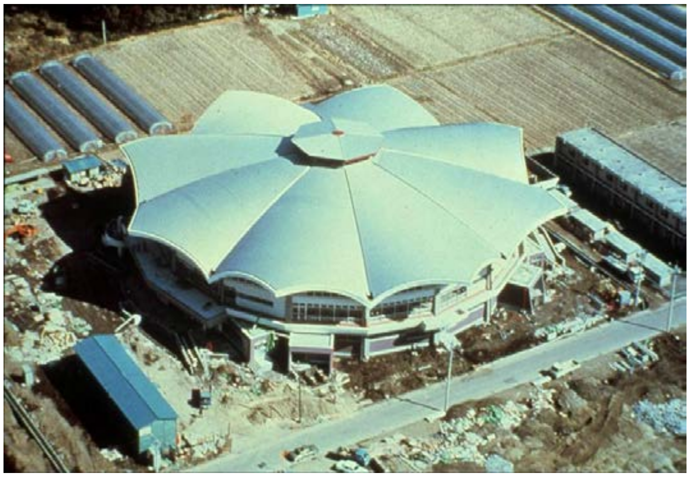

Fig 2 An aerial view of a gymnasium, Japan (Tomoe Corporation)

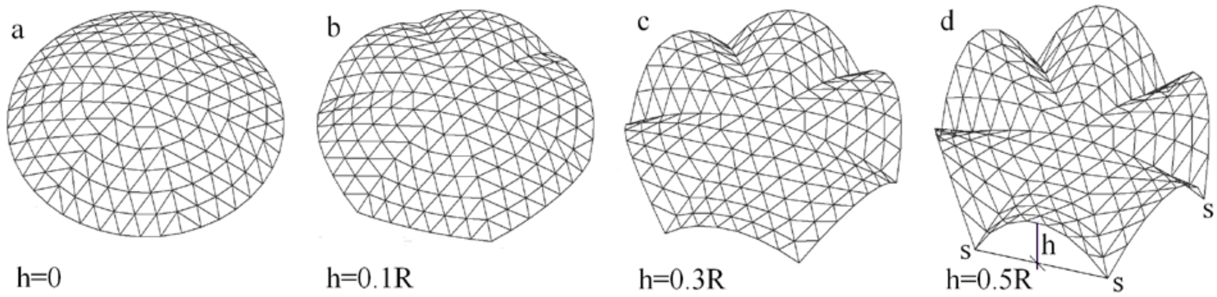


Fig 3 Scallop domes with various amplitudes

A scallop dome consists of a number of arched sectors (H Nooshin et al, 1997, H Nooshin, and P Disney, 2002). The dome of Fig 2 has eight sectors. Figure 3, shows four scallop domes with six sectors. The central rise of the edge arch of a sector is referred to as the amplitude (the parameter h of dome ‘d’ on the right). In the domes of Fig 3, the amplitude varies from zero in dome ‘a’, to a maximum of h=0.5R, in dome ‘d’, where R is half of the span of the domes. Dome ‘a’, is the base on which scalloping has taken place.

Changing an aspect of a form, in general, will have different consequences and implications and it can be looked upon from various points of views. For instance, changing the amplitude of a scallop dome will affect:

- The geometric particulars of the dome such as the length and the approach angle of the elements (that is, the angle of an element relative to the connection), the occupied volume, ....
- The self-weight, the response to environmental loads such as wind, snow, rain, temperature change ...
- The acoustic response, the response to natural (day) light, sun shading,...
- The cladding details, connection details, the architectural details,...
- The functionality and visual impact,...
- The structural response such as natural frequencies, strength, stiffness, support reactions,...

- The methods of construction,...
- The methods of maintenance,...
- The economy,...

The items listed above, are only for exemplifying purpose, and in general, an architectural form may have much wider and more diverse range of aspects. A review of the list shows that, various features of the domes will change due to the variation in the parameter h. The above mentioned items could be classified in two groups of measurable and non-measurable aspects.

Now, suppose that a designer has to select a dome from the set of domes of Fig 3. What are her/his criteria for this selection? Some of these criteria relate to measurable engineering considerations such as safety, strength and economy. In addition to the engineering criteria, an aspect such as visual impact of a dome could be the selection criteria. Visual impact is a non-measurable (and not easily definable) architectural aspect of a form. The selection is, in general, based on the two-fold criteria of engineering and non-engineering (subjective) considerations. But both of these classes of criteria have roots in desirability. In fact, there are different and distinct interpretations on engineering measures and considerations as well.

The discussion on the desirability of an entity of the form are accompanied with phrases such as 'excellent', 'very good' ... 'not good' and the like. Suppose that the domes of Fig 3 are to be classified with such conventional phrases regarding their degree of desirability. Then, regarding the domes of Fig 3, one may say, for instance:

{[a, is 'good'], [b, is 'very good'], [c, is 'the best'], [d, is 'not good']}

With this type of expression, it is very difficult -if not impossible- to carry out useful and further manipulations. It is possible, however, to express the degree of desirability of every aspect of the form numerically, and this type of expression is more useful for design considerations.

To express the level of desirability regarding the visual impact of the domes, one can use various numerical scales. For instance, the scale of 0 to 1 can be used for this purpose. Therefore, any number between 0 and 1 will represent the attitude of the designer in this respect. Within this scale, a higher number means a higher degree of desirability. A number, '1' represents 'the highest degree of desirability' and '0' represents 'the complete absence of desirability'. Based on this definition, the numbers associated with the domes could be regarded as 'desirability factors'.

A desirability factor, explicitly and clearly defines the level of preference. For the set of four domes of Fig 3, let the following list of desirability factors be assigned:

$f$= {0.5, 0.75, 0.9, 0.4},

where, the numbers 0.5, 0.75,....and 0.4, are associated with the domes a to d, respectively. Thus, dome c, has been given the relative highest desirability factor of 0.9, and dome d has been given the lowest desirability.

Now that the degree of desirability of a design aspect is expressed numerically, the question is how it can be useful in the design process?

Suppose that the domes of Fig 3 are the evaluative models in a design process, and suppose that the criteria of evaluation of the models, relates to the realm of structural engineering. The domes have the same diameter, are single-layer lattice type with moment resistant connections, and each dome has six supports at the valley points 's', as shown in a few places Fig 3d. The members of the domes may assume a section from a list of steel square hollow sections, and are proportioned according to a certain design code of practice in the most economical way for a gravitational load, uniformly applied all over the domes.

For a set of numerical data, a measure of the stiffness of the domes is given in terms of (force/displacement) as:

K= {18.7, 3.1, 53.9, 100},

where, K is the normalised stiffness of the node at the crown of domes a to d of Fig 3. Here, dome d has the highest stiffness and possibly the most desired one, from a purely engineering point of view. The desirability factors associated with the visual impact of the dome are already given as:

$f$= {0.5, 0.75, 0.9, 0.4},

To combine the engineering results and the visual desirability, the elements of the list $K_m$ are obtained by multiplying the elements of the list K and the corresponding elements of $f$, as follows:

$K_m = f \times K$ = {9.35, 2.33, 48.51, 40},

The logic of multiplying the desirability factors with the engineering preferences is that one is encountered with two different classifications of preferences and the desirability factors can act as multipliers to combine the effects of the two classifications.

Here, according to the list $K_m$ dome c, has the highest stiffness, and is therefore, the most desirable dome from both architectural and structural engineering points of view.

In cases where, the minimum-value of a design criterion is sought, the above mentioned approach which applies to the maximum-value criteria slightly has to be changed. As an example, suppose that, W is the normalised list of the weights of the domes, with the weight of the heaviest dome being considered as 100:

W= {90.1, 78.1, 83.2, 100}

Minimum weight of structures could be a design goal, therefore, dome b with the relative least weight of 78.1, is the most preferred dome. In order to find the effect of the desirability factor $f$, on the weight list W, first a list M is obtained by finding the inverse of the elements of W:

M= {11.1, 12.8, 12, 10}$\times \frac{1}{1000}$

All numbers of list M have the common multiplier ($\frac{1}{1000}$). Now, the problem of minimising W has changed to the problem of maximising of M. The maximum value of list M, 12.8 corresponds to the minimum value of the list W, that is, 78.1 which is the relative weight related to dome b. Multiplying the desirability factor $f$, by list M, in the same way that it was done for the list K, will in effect modify the weight list W:

$W_m$= $f$ x M = {5.55, 9.6, 10.8, 4}$\times \frac{1}{1000}$

According to the modified weight list $W_m$, 10.8 is the maximum and corresponds to dome c, and is the most desirable dome by the twofold combination of the desirability list $f$ and the analytical results.

Having introduced the concept of desirability factor, some discussion in this respect is useful:

If all of the desirability factors in a list $f$ are equal, then, these factors will have ‘no effect’ on the outcome. In such a case the design decisions are made only on the analytical results. For instance, the desirability list $f$= {0.5, 0.5, 0.5, 0.5}, will give rise to the choice of domes d and b, according to the stiffness criteria (K) and the weight criteria (W), respectively.

In the example under consideration, there was only one desirability list defined and all other decisions regarding the domes were left to the engineering considerations. And, only one area of engineering, namely, the structural engineering was considered. The members of the domes were structurally proportioned based on a selected list of hallow square sections. But, infinitely many other sections could be used as well. Additionally, a criterion such as ‘W’, that is, the weight of the domes was used as a measure for comparison of the domes. It may happen that for another designer other criteria, say, the construction method to be more important than the weight criterion. The discussion reveals the fact that, in designing of forms, not only the non-quantitative aspects such as the visual impact, but, also, every engineering decision on the quantitative aspect of the form, involves the personal preference and desirability of the design engineer. Generally speaking, a decision has to be made at each design step and every decision concerns desirability. It does not undermine the science and engineering advice available in a very wide range of areas and aspects of form, but it emphasises the twofold nature of any decision regarding a form: desirability + engineering.

The designer is the only person to decide on many aspects of the form. For instance, degrees of ‘comfort’ and ‘pleasantness’ of architectural spaces are not easily definable. Also, temperature, humidity and sound, are among the measurable aspects, but their ‘acceptable and pleasant’ ranges could be different for different people. Aspects such as ‘privacy’ of living spaces, has dissimilar meanings and interpretations in different cultures and societies. The aspect of ‘circulation path’ has different values for an exhibition hall, an air terminal, a school, a library and an office from the point of view of different architects. Interior decoration of houses, offices,... has to rely mainly on the personal preferences. As an example, suppose that in an office a number of desks and plant/flower boxes are to be arranged. There are many complicated aspects to be considered. For instance, circulation path, degree of occupancy of the area, privacy of each person, allergy of persons to plants, the natural draught-artificial ventilation, type of the duties of the persons and the required minimum area, the required light, the noise, ....

Considering the above given discussions, it is essential that the preferences of the designer regarding various aspects of the form under design, to be associated with the evaluative models within the digital design media.

## 2 METHODS OF DEFINING DESIRABILITY FACTORS

As many as there are possible choices for an aspect of a form, there could be associated desirability factors. There are various methods for defining a desirability factor. In the previous section, the desirability factors were given through by a ‘desirability list’. In the present section, more examples regarding the methods of defining desirability factors are given. The methods, in general, may involve lists, mathematical expressions, diagrams, as well as, interactive definitions based on the analytical results.

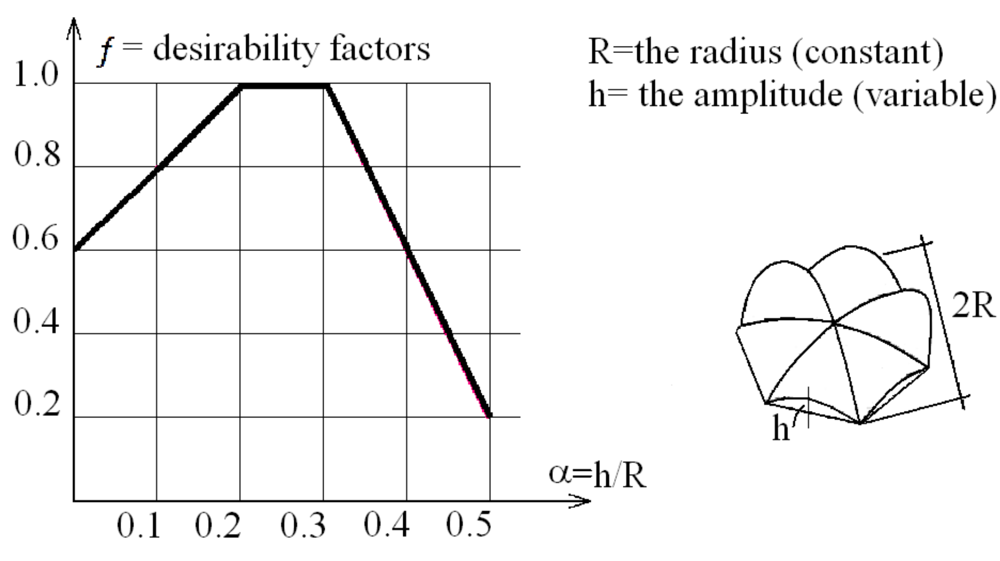


Fig 4 A desirability diagram

- Figure 4 defines the desirability factor as a function of the ratio $\alpha$=h/R, for a family of scallop domes. The amplitude of the domes can assume any value in the range [0, 0.5R]. The figure shows that the desirability factor $f$=1, for $\alpha$=0.2 to 0.3, and has the minimum value 0.2 for $\alpha$= 0.5. Here, the desirability factors are defined in terms of a diagram instead of a numerical list. The desirability diagram of Fig 4, also, defines the allowable range of variable $\alpha$. The desirability diagrams are useful for cases where there are numerous possible variants.

- Figure 5 shows the plan and side view of a pedestrian bridge over a valley in a wooded region. The particular plan shape of the deck is to provide a suitable platform for an uninterrupted view of the surroundings of the bridge. The deck is supported by three columns at points A, C, D, and a pylon OP as shown in the side view of the bridge. The pylon at point P supports a main cable APB which is connected to a number of hanging stay cables. The deck of the footbridge is suspended from these stay cables at the inner side of the loop ASBR of the bridge deck. This type of supporting of the bridge deck from the inner side of the deck is similar to the idea of an S-shape footbridge, at Bochum, designed by J Schlaich and R Bergermann, 2003 (A Bögle et al, 2005).

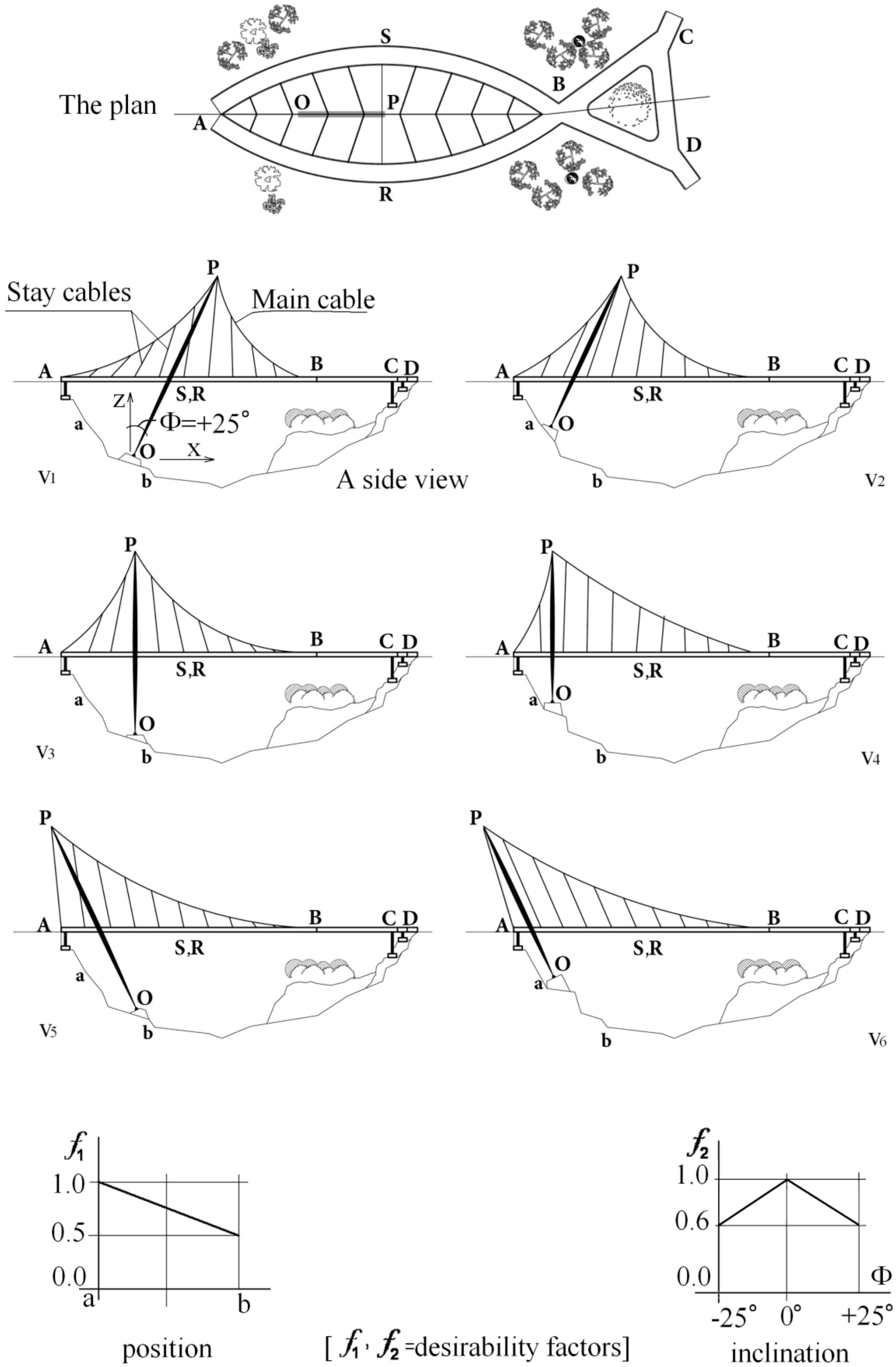


Fig 5 Use of desirability diagrams for a pedestrian bridge

In designing the details of the bridge of Fig 5, it is intended to investigate the effects of the variation of the position of pylon OP. This investigation is to cover both the effects from an engineering point of view as well as those regarding the visual impact of the bridge. Regarding the base O of the pylon, the shape of the valley provides a region along the curve ab that suits the positioning of the foundation of the pylon. The choice of a point along ab for the foundation would of course affect the position of the pylon. The pylon's position is also altered by the angle Φ between the axis of the pylon and the z-coordinate axis (see side view in Fig 5). A number of variations concerning the position of the pylon are shown in Fig 5, where the height of the top point of the pylon (that is, z-coordinates of point P) is kept constant.

The desirability diagrams $f_1$ and $f_2$ of Fig 5 are associated with the pylon OP of the bridge. In the desirability diagram $f_1$, point a, is the most preferred position of the base point of the pylon. Also, in the desirability diagram $f_2$, the inclination of 0° (with respect to the vertical axis z) is the ideal value of angle Φ.

The effects of the variations of the position of the pylon may be investigated from many different points of view. However, for this particular example, the investigation is limited to the horizontal movement of point P of the pylon in the x-direction, and the vertical deflection of point B of the deck of the bridge. These parameters are, in effect, measures of the stiffness of the footbridge. To investigate the structure, the six variants of the bridge $v_1$ to $v_6$ whose longitudinal side views are shown in Fig 5 are analysed. The displacements of points P and B under the gravitational dead and live loads, for an assumed geometry (and set of numerical data) of the bridge, are obtained respectively, as

$D_P = \{149, 195, 78, 138, 33, 186\}$,

$D_B = \{116, 244, 161, 299, 402, 542\}$, The displacements are in mm, and they are related to the following positions of the base point O, and the angle Φ, of the pylon

C= {b, a, b, a, b, a},

Φ= {+25°, +25°, 0°, 0°, -25°, -25°},

respectively. The lists C, Φ, $D_P$ and $D_B$, given above, contain the data and the output of the analysis for the variants $v_1$ to $v_6$ of Fig 5. Thus, for $v_1$ and $v_4$, one has [b, +25°, 149, 116], and [a, 0°, 138, 299], respectively.

The desirability factors for variants $v_1$ to $v_6$, extracted from the desirability diagrams of Fig 5, are

$f_1$= {0.5, 1, 0.5, 1, 0.5, 1} and

$f_2$= {0.6, 0.6, 1, 1, 0.6, 0.6}

In the case of present example, applying the desirability factors to the results of analysis, is not as straightforward as the example of section one. The two desirability factors, first, have to be 'combined'. If, it is assumed that the parameters C and Φ, have the same 'value' for the designer, then, their corresponding desirability factors $f_1$ and $f_2$, will have identical values as well. And therefore, the operation of averaging can be used to combine the two desirability factors

$f$= {0.55, 0.8, 0.75, 1, 0.55, 0.8}

Now, the rest of the process can proceed as before, by assuming that a smaller value of displacement is more favourable from the engineering point of view. Then, the inverses of $D_p$ and $D_B$ are multiplied by the desirability factor $f$, as explained in section one,

$D_{pm}$= {3.69, 4.1, 9.62, 7.25, 16.67, 4.3}$\times \frac{1}{1000}$,

$D_{Bm}$= {4.74, 3.28, 4.66, 3.34, 1.37, 1.48}$\times \frac{1}{1000}$

According to the modified displacement lists, $D_{pm}$ and $D_{Bm}$, the variant $v_5$ and $v_1$, have, respectively the highest stiffness and are the preferred variants from the point of view of the analytical measures combined with the desirability values.

The averaging of the desirability factors, as applied above, assumes that the participating aspects all have the same importance. However, if the considered aspects of a form, have different levels of importance for the designer, then, a multiplier $0<\lambda\leq 1.0$, could be applied to the desirability factors associated with them, according to their degree of importance. Otherwise, $\lambda=1$, is assumed for all aspects.

The same type of combined desirability factors may be obtained, where several persons suggest different desirability factors for the same aspect of the form. The multiplier $\lambda$ could also be applied in this case, to consider the difference in ranks of the participants in the suggestions of the desirability factors.

- Desirability factors can be assigned to any varying aspect of a form. To exemplify this, consider another type of variation for the footbridge of Fig 5, as shown in Fig 6a. The figure shows the plan of the centreline of the loop ASBR of the bridge of Fig 5. Here, it is assumed that the positions of points A and B are fixed. But, the shape of the bridge deck could change with respect to its initially assumed centreline of Fig 6a.

To elaborate, suppose that the hatched area of Fig 6b defines the region in which the geometry of the (plan) of the bridge deck can change. In other words, the hatched area defines the 'extent' or the 'tolerance' area for the base arc ('zero-arc', which means, the initially given geometry) of the bridge. There are infinitely many possibilities for the definition of the variants of the bridge deck within the hatched area. But, here, a simple method is suggested for generating of the variants of the bridge deck based on its initial geometry, that is, the looped arc ASBR. In order to explain the method of generating the variants of a given base arc, consider Fig 6c and suppose that the initially defined arc is jk. Now, let points j and k move to new positions ($j_1$, $k_1$) in the direction (side) 1, and ($j_2$, $k_2$) in the direction (side) 2, respectively, as shown in Fig 6c. Furthermore, it is assumed that the steps of movement $jj_1$, $kk_1$, $jj_2$ and $kk_2$, are normal to the base arc jk.

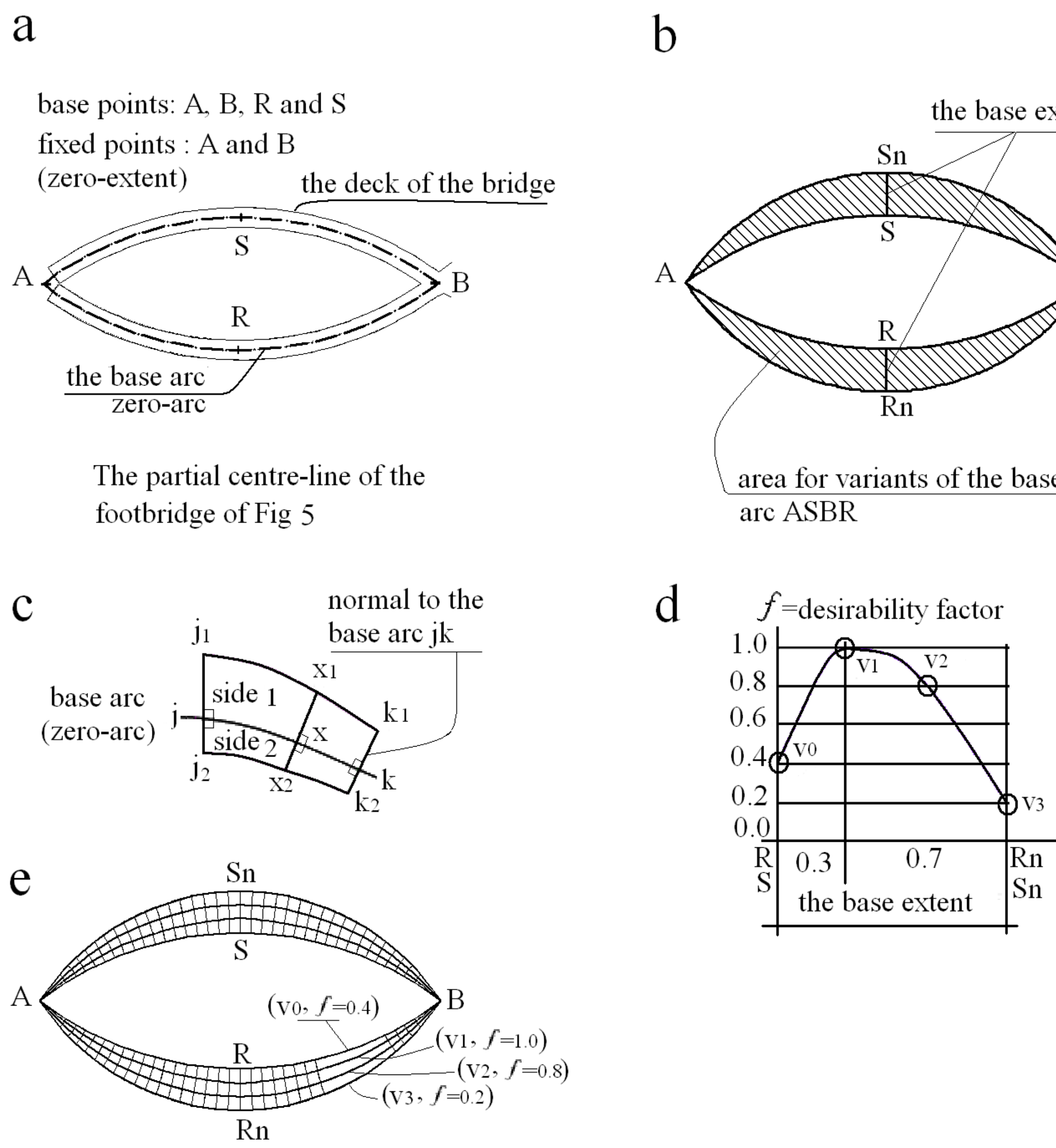


Fig 6 Defining desirability diagram in terms of the shape of an arc

Under these assumptions, the points $x_1$ and $x_2$, are the new positions of a typical point x, of the arc jk, on the sides (in the directions) 1and 2, respectively. Where,

$$xx_1 = jj_1 + (kk_1 - jj_1)\frac{\text{arc length(jx)}}{\text{arc length(jk)}}$$

$$xx_2 = jj_2 + (kk_2 - jj_2)\frac{\text{arc length(jx)}}{\text{arc length(jk)}}$$

Thus, the new position of a point x, is obtained by linear interpolations of movements of j and k. The arcs $j_1x_1k_1$ and $j_2x_2k_2$, are considered as two variants of the base arc jxk. For the arc jk, the points j and k, with known extents (steps of movements), are referred to as the 'base points'.  Here, it is assumed that the arc jxk does not have 'sharp and abrupt' changes. For the loop ASBR of the bridge, the points A, B, R and S are assumed to be the base points. There could be several base points for an arc. The points A and B have a zero extent, and the extent of the points R and S, in the outside of the loop, are RRn and SSn, respectively (Fig 6b). Then, the new position of any point x of the arc segments ASB and ARB could be obtained in terms of the movement of its base points. Thus, the variants of arc ASBR could be generated within the hatched area of Fig 6b. For instance, if the extents SSn and RRn are divided into three steps, then, considering the base arc as a variant of itself, four variants of the base arc ASBR are generated (Fig 6e). In obtaining a variant, the steps of movement are assumed to be normal to the previously obtained variant (rather than the initial base arc). In a manner, similar to the outward direction, the variants of the inward direction of the loop ASBR could be obtained. Now, suppose that the desirability diagram for the variants of ASBR is given as a function of the extent of the base points S and R (Fig 6d). Figure 6e, shows four variants $v_0$ to $v_3$ of the base arc ASBR, together with the associated desirability factors, which are extracted from Fig 6d and are shown on the desirability diagram.

In designing the footbridge with the layout of Fig 5, the desirability diagrams of Figs 5 and 6 could be used for various purposes. For instance, architecturally, these desirability diagrams may be the basis for evaluation of the panoramic views offered to the pedestrians at various positions of the footbridge and could be combined with the results obtained from engineering disciplines.

## 3 DESIRABILITY FACTORS AND INITIAL SKETCHES

Traditionally, hand-drawn sketches have been the designer's starting step. The use of sketches is clearly an important part of natural process of designing (N Cross, 1999).  The aim is to record the most significant features of the form to be built. As a rule, the initial sketch lacks the detailed design information. The change from the initial sketch to the final design occurs by the evolutionary process of design. The initial sketch has to be refined according to the architectural, structural, mechanical and other requirements to come up with the final design. For example,  consider Figs 7 to 9, which show the initial sketches and the final designs for Terminal 5 of Heathrow Airport (proposed by Grimshaw, 1991),  a section of the roof of the main terminal of Kansai Airport, Osaka Japan (Renzo Piano, Building Workshop, 1989) and the California Academy of Sciences (Renzo Piano), respectively. A comparison of the initial sketches with the respective finalised designs reveals that the shapes of the finalised designs have a good resemblance to the initial sketches. However, the finalised designs are not of course identical to the sketches and contain much more precise information.

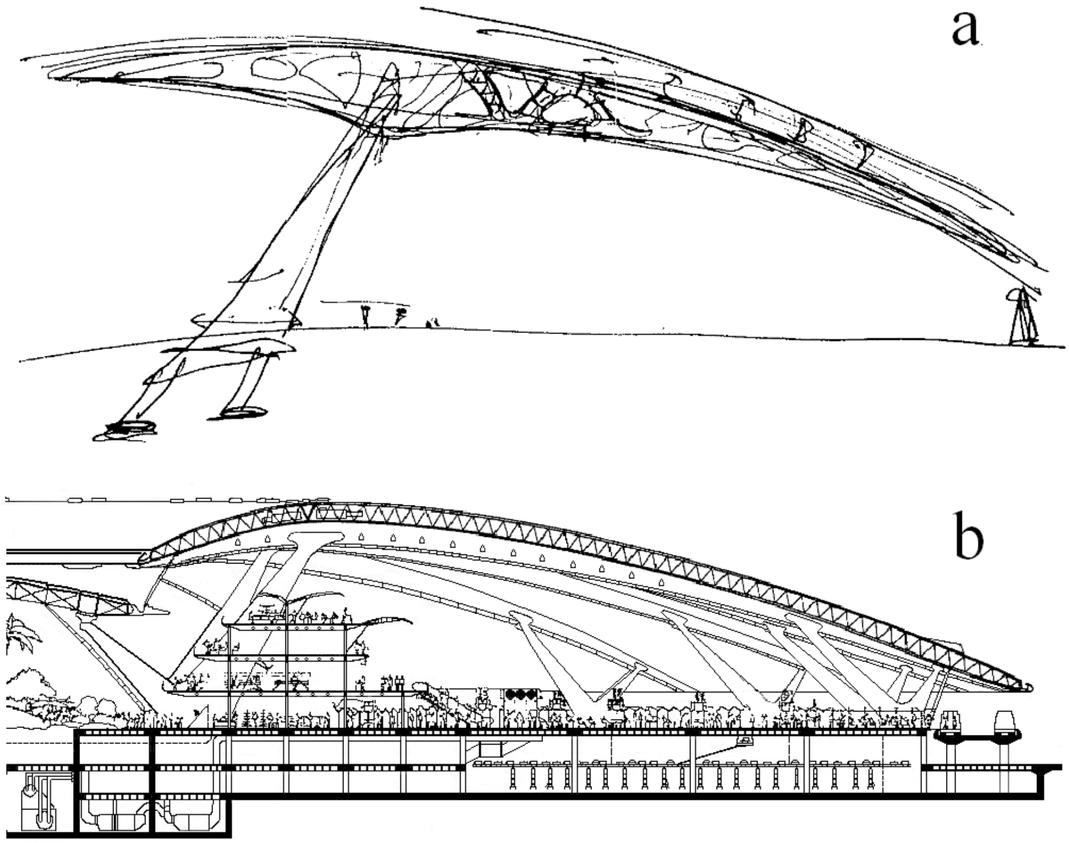


Fig 7 Initial (a, top) and Finalised (b, bottom) proposal for Heathrow Terminal 5

Nicolas Grimshaw exhibited at Venice Biennale 1991 (B Edwards, 1998)

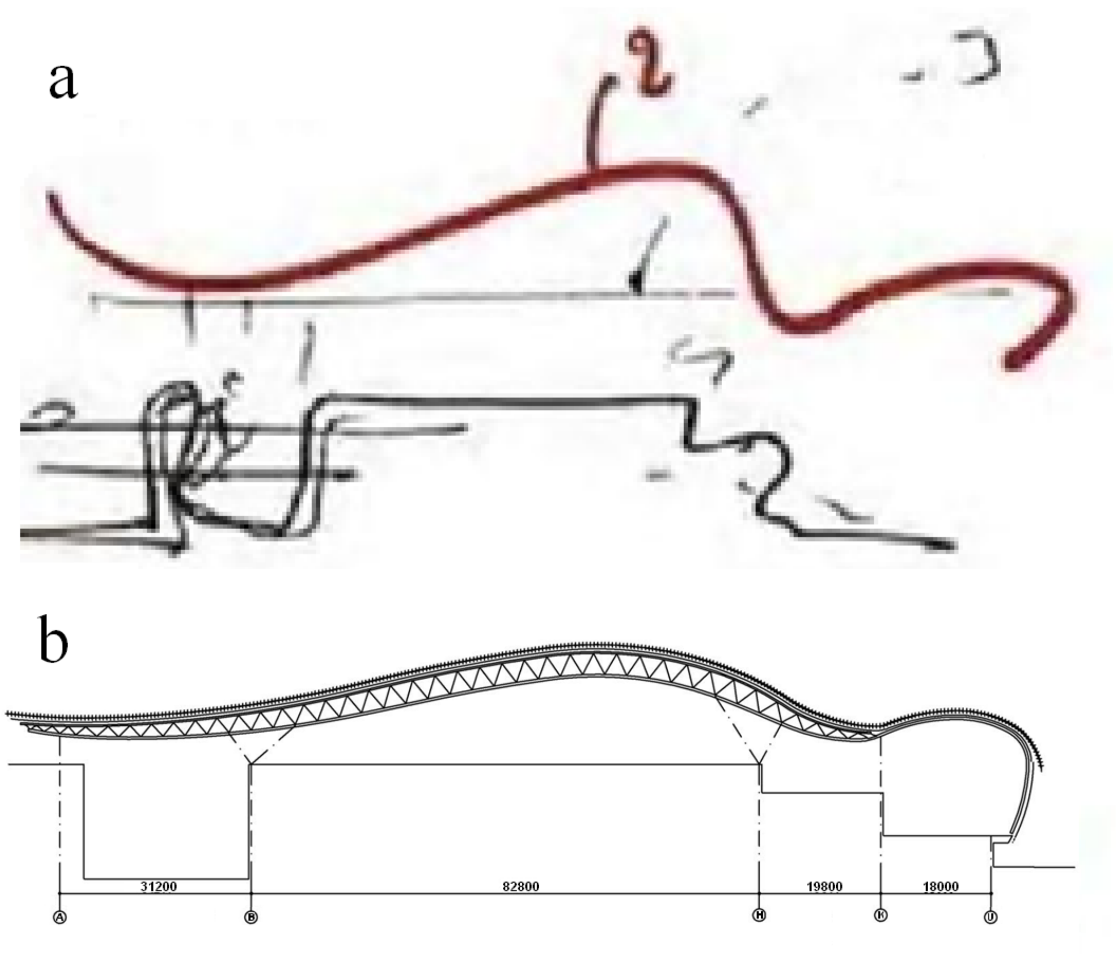


Fig 8 a (top) Part of the initial sketch, b (bottom) The finalised section,

The main terminal of the Kansai Airport, Osaka, Japan,

Renzo Piano Building Workshop (renzopiano.com), Ove Arup Consulting Engineers

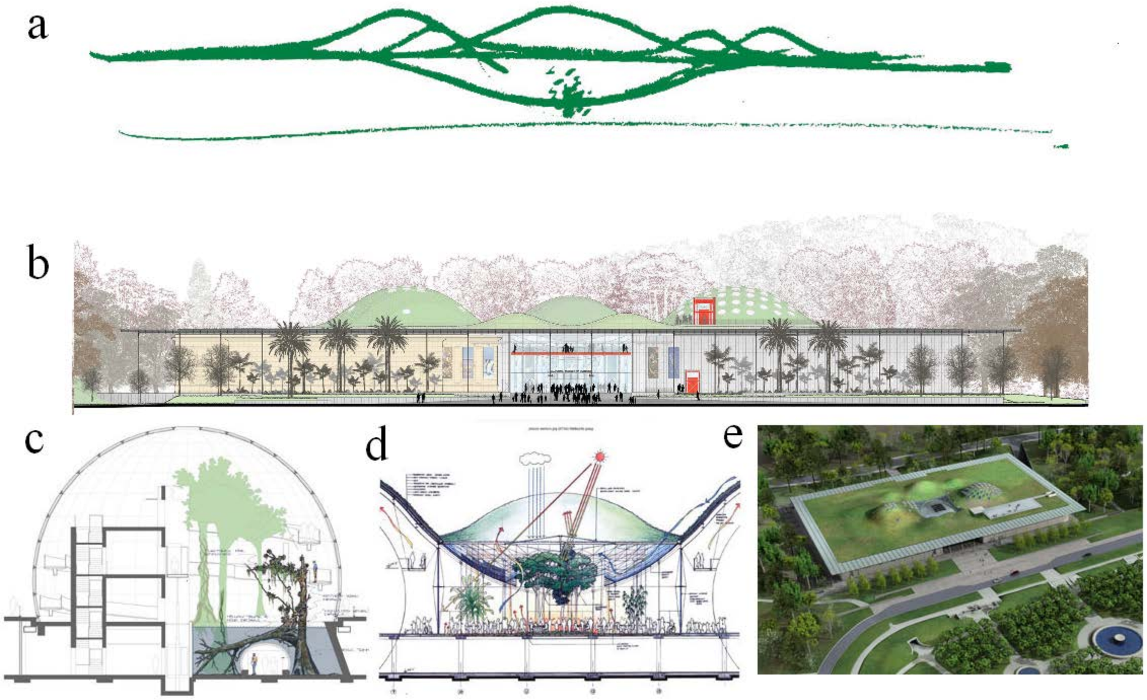


Fig 9  a The initial sketch (basic idea), b to d Development of the basic idea,

e A view of the final structure, California Academy of Sciences,

Renzo Piano Building Workshop and Arup Consulting Engineers

The way that the form of the initial sketch and the related data are interpreted in design process, does not follow a well-defined and simple method. However, it is clear that a sort of optimisation is involved in this transformation. The degree of change of an aspect of the initial sketch compared to the final design, somehow, is inversely related to the degree of ‘desirability’ of that aspect of the initial form. Thus, a ‘low’ degree of change of a feature, may, indicate that the feature has had a high desirability level. On the other hand, a high degree of change indicates that it has had a low level of desirability. Fuzziness is an inherent nature of the geometry of the sketch. Therefore, a desirability factor given to the sketch, intriguingly, is related to its degree of fuzziness as well. Phrases such as ‘not sure’, ‘pretty sure’, ‘absolutely sure’ that are customary and meaningfully used in relation to initial forms, reflect the degree of certainty of the designer regarding various aspects of the design. By comparing the forms of the initial and the final design, one could classify the degree of the changes that occurred as, say, low, moderate and high and so on. Here, the ‘degree of change’ rather than the ‘reason for change’ is the centre of attention.

If the process of refinement of an initial sketch is to be carried out by computer, then, the digital media should acquire information on the parts that are preferred to be left untouched, the parts that could be changed freely and so on. Therefore, the steps for transformation of the initial sketch as the basis for the shape of the final design in a digital media, should take into account the personal preferences and the way of thinking of the designer. And this needs high-level conceptual schema that guides shape manipulations (R Oxman, 2002). The first step in this way is to input the hand-drawn sketch into the digital media, by appropriate devices such as scanners. Most of the digitised free-hand sketches cannot be used for engineering purposes directly, because they have ambiguities or do not have enough information such as scale and dimensions, therefore, they have to be refined and synthesised. The next step consists of filtering graphic noises and removing ambiguities, classifying line thickness and colour, scaling and dimensioning of sketch and identifying the boundaries (fixed points). The attention, here, is focused on the general geometry as the main message of the sketch and all the other data conveyed by the sketch is ignored. The end product of this step is referred to as a ‘zero-sketch’. The geometry of the zero-sketch is clearly known and could be used for engineering purposes. A zero-sketch, normally, is a clue to the definition of a ‘family’ of geometric shapes rather than a single and unique geometry. The acceptable ranges of deviations from the geometry of the zero-sketch are defined by ‘tolerance space’, which allows for the creation of geometries ‘similar’ to the geometry of the zero-sketch. Obviously, the definition of tolerance space should follow the desires of the designer.

A method of defining tolerance space was given for the pedestrian bridge in Fig 6. The ‘base arc’ ASBR and the ‘base extent’ SSn and RRn of Fig 6 could be viewed as a ‘zero-sketch’ and ‘the tolerance space’, respectively. Then, by a method similar to the method used in Fig 6, variants (evaluative models) of a zero-sketch could be generated. In this way, the hand drawn initial sketches could be used within the digital media and the desirability factors (diagrams) could be associated with the variants. In order to be able to generate the variants of an initial sketch, it is necessary that the base extent (tolerance space) to be known, which could be defined as part of the initial (hand-drawn) sketch. With sufficient data, the idea could be extended to the three dimensional geometries.

## 4 CONCLUDING REMARKS

The designers are facing new situations today. Advent of high technologies, availability of materials with diverse properties, and sustainability issues require different types of analyses and evaluations on the architectural forms. The scientific/engineering analyses include energy analysis, study of circulation and access pattern, lighting, ventilation and heating, as well as acoustic ... and aesthetic considerations. Furthermore, the environmental performance of forms regarding the effects of sun, wind ...and snow are to be investigated. Architectural design is engaged with complex free form geometries (P Zellner, 1999).

Computers have improved the efficiency of the design processes, have provided means of collection of information regarding diverse design aspects and disciplines in a single digital model, and have provided more systematic ways of working. The hand drawn initial sketches and paper-based drawings are gradually replaced by digital shapes and objects. Buildings are now designed, documented, fabricated and assembled with the assistance of digital means. Physical objects can now be captured digitally and translated into digital models and vice versa (L Sass, and R Oxman, 2006).

On the other hand, human decisions regarding an aspect of the form have, always, a flavour of desirability. Existence of a measurable basis for an aspect of design, naturally, increases the rationality of the decision, but does not exclude human personal inclinations. Also, the absence of scientific measures in an area strengthens reliance on the experience, insight and judgment of the designers.

Considering the discussion given above, it is seen that the architectural design is a multi-facet complicated process, in which the decisions and personal preferences of the designer are essential. The example of Section I showed that the personal desirability of the designer can be associated with the evaluative models, and can be combined with the results obtained from various engineering disciplines. The method is general and could be applied to any aspect for architectural design of form.

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