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Analysis of lines and forms in buildings to rural landscape integration

L. García-Moruno[1]*, M. J. Montero-Parejo[2], J. Hernández-Blanco[2] and S. López-Casares[2]

[1] *Departamento de Expresión Gráfica. Centro Universitario de Mérida. Universidad de Extremadura. C/ Santa Teresa de Jornet, 38. 06800 Mérida (Badajoz). Spain*

[2] *Departamento de Expresión Gráfica. Centro Universitario de Plasencia. Universidad de Extremadura. Avda. Virgen del Puerto, 2. 10600 Plasencia (Cáceres). Spain*

Abstract

In many developed countries the recent increase in tourist and farm buildings in the countryside has seriously jeopardized the attractiveness of natural and traditional views; such is the case of inland Spain. Visual and aesthetic aspects of any object are defined by their colour, form, line, texture, scale and spatial character. This paper investigates lines and forms and tries to develop design criteria that could offer a high probability of achieving a building integration class as good or very good. The main aim of this research is to develop guidelines for future municipal planning laws, which could help professional designers and town council planners to select lines and forms that harmonize architectural design and environmental location. The proposed approach studies the relationship between buildings and their background. A method is developed to assess these visual relationships among building characteristics of lines and forms and the landscape ones. Also, this research includes public survey methods to assess building integration preferences and a summary table for systematic application of the suggested methodological process. Relevant correlations have been obtained, for example, whereas a type of relationship (visual continuity) provides a probability of 72% of achieving an integration class as good or very good other one (poorly compatible contrast) provides 0%. These relationships between different types of visual characteristics are satisfactory for the study of integration quality. Objective design guidelines are obtained and it is possible to make an evaluation of the different alternatives available and to select the most suitable according to the type of integration sought.

Additional key words: building design, public survey, visual integration.

Resumen

Análisis de líneas y formas de las construcciones para la integración en el paisaje rural

En muchos países desarrollados el reciente incremento de edificios turísticos y agrícolas en zonas rurales ha puesto en grave peligro el atractivo de su riqueza natural y cultural, como es el caso de las zonas de interior de España. Los aspectos estéticos y visuales de cualquier objeto quedan definidos por su color, forma, línea, textura, escala y, en el caso de las escenas, caracteres espaciales. Este artículo examina las líneas y formas e intenta desarrollar criterios de diseño que ofrezcan una alta probabilidad de conseguir integraciones de edificios clasificadas como buena o muy buena. El principal objetivo de esta investigación es elaborar directrices para futuras legislaciones de planificación municipal, que puedan servir de ayuda a profesionales del diseño y planificadores de ayuntamientos a elegir aquellas líneas y formas que armonicen el diseño arquitectónico y la localización en el medio. La aproximación propuesta estudia las relaciones entre edificios y su entorno. Se desarrolla un método para valorar las relaciones visuales entre las características de las líneas y formas de los edificios y las de los paisajes. Esta investigación incluye también métodos basados en encuestas públicas para valorar las preferencias de integración de edificios y una tabla resumen del proceso metodológico propuesto. Se han obtenido correlaciones relevantes, por ejemplo, mientras que un tipo de relación (continuidad visual) proporciona una probabilidad del 72% de obtener una integración clasificada como buena o muy buena, otro tipo (contrastes poco compatibles) proporciona el 0%. Estas relaciones entre diferentes tipos de elementos visuales han sido satisfactorias para el estudio de la calidad de la integración. Se obtienen directrices de diseño objetivas y es posible hacer una evaluación de diferentes alternativas para seleccionar la más adecuada de acuerdo al tipo de integración perseguido.

Palabras claves adicionales: diseño constructivo, encuesta pública, integración visual.

* Corresponding author: lgmoruno@unex.es
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Introduction

For hundreds of years, the location and design of rural buildings depended almost exclusively on climatic conditions, the requirements imposed by the work system and access to building materials. Buildings were carefully sited and oriented, resulting in a close relationship between the building and the landscape. Forms, materials and colours are harmonised with the surroundings and frequently enhanced (Di Facio, 1989).

In recent decades, agriculture and tourism have experienced an important transformation. Buildings have proliferated and in many cases are discordant with their surroundings (Montero *et al.*, 2005). It is important that these new buildings should be designed and sited respecting their environmental emplacement (Tandy, 1979). However, traditional construction styles and materials do not always match modern agricultural needs. Therefore, the designer must bear integration and functionality in mind and plan buildings satisfying both criteria. Different design methods have been proposed to achieve it (Tandy, 1979; Bell, 1995, etc.).

Human appreciation has guided the desire to preserve and improve the landscape (Brunson and Reiter, 1996). The countryside is worthy of recognition as a factor that should influence the location and design of buildings (ELDC, 1979; Scottish Environment Department, 1993). For this reason, objective design guidelines are necessary.

Several factors must be considered in order to understand the problem that arises from the relationship between a building element and the landscape (Ayuga, 2001):

— *The landscape value*. Landscape assessment is a matter that has been widely discussed (Shafer, 1969; Smardon, 1979; Bishop and Leahy, 1989; Tveit *et al.*, 2006) but from the point of view of building integration a simple quantitative method can be used. For instance, Cañas *et al.* (1996) elaborated a methodology to deduce valuation (0-100) of any landscape for any person from physic and psychological parameters. Therefore, the effect of the intervention can be taken into account and related to the landscape value.

— *The location of the building.* The landscape integration of a building commonly depends more on the correct choice of place than on any other consideration. In order to study the location in depth, planning limitations, opportunities, visual characteristics and the scene should be considered. Geographic Information Systems offer useful tools for these purposes (Hernández *et al.*, 2004a,b).

— *Colour, texture, line and form:* these are visual elements that characterize the landscape (USDA Forest Service, 1974; Table 1). Once a place has been selected, a detailed study of the scene in which the building is going to be placed should be carried out. In each scene, the colour of the main elements (vegetation, soil, other buildings, etc.), textures, and lines and forms should be considered, among others. A methodology for data acquisition needs to be drawn up (García *et al.*, 2003, 2006).

— The *kind of traditional buildings*, their colour, texture, volumes, strength lines and harmonies. The design of new buildings must consider traditional buildings as an important part of the surroundings.

— The *kind of construction elements*, their position and repetition within the building, the feasibility of alterations and their cost, etc. Each construction element can be studied to adapt better to the landscape and tra-

Table 1. Visual and aesthetic elements (Español, 1995)

Elements	Characteristics
Surface properties	
Colour	Spectrum Saturation Lightness
Texture	Regularity Density Grain size Internal contrast Formation elements
Line	Sharpness Complexity Direction
Form	Geometry Complexity Direction
Composition elements	
Space	Scenic composition Scenic background Siting of units
Scale	Scenic occupation Contrast of scales

Abbreviations used: CC (compatible contrasts), DWC (diversity without contrasts), PCC (poorly compatible contrasts), VC (visual continuity).

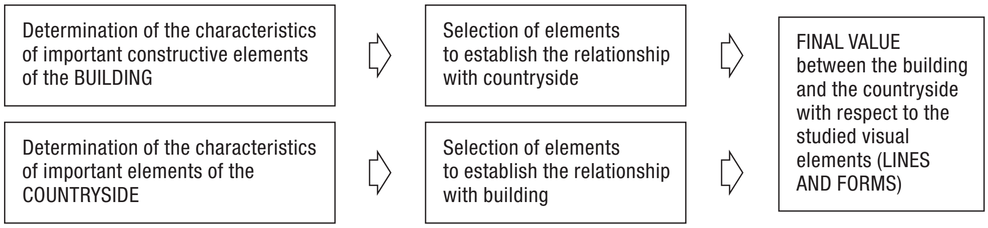


Figure 1. Depiction of the proposed approach.

ditional construction. In some cases the selection of these elements may be enough to ensure success. In others, cheaper alterations in their visual attributes may help, that is: colour, texture, shape, as well as the use of some repetition rules.

— With respect to *lines*, *forms* and other elements, knowledge of the *observer's position* helps explain the conditions under which a visual study was performed. For this reason, the selected images for any study must be taken under habitual observer conditions for most viewers. If it is usually a sunny region, the selected image must reflect this, the photo must be taken from a nearby road or tourist vantage point (it defines the distance), etc. *Observer conditions* tend to affect the perceived lines and forms of objects because of distance, atmospheric conditions, angle and direction of vision, and direction of incident light.

All of these factors should be considered for undertaking any study which tries to develop those design criteria that could offer a high probability of achieving a building integration as good or very good, from the point of view of human perception. In this context several researches have already taken the aforementioned aspects into account. However, only few ones have focused on lines and forms of the buildings and its suitability for a good visual integration into the landscape. In this sense, it is proposed a methodological framework in order to quantify how lines and forms could be affecting visual perception of building for most of the population. Thus, characteristics of lines and forms (Table 1) will be studied and measured in order to establish their interrelationship with the environment. In case lines and forms of buildings are related with countryside ones, these interrelationships could provide information about the building visual integration.

This paper presents characteristics of lines and forms and the different relationships between types of any of these characteristics in relation to natural ones. Finally, an approach method for evaluating the quality of visual integration of lines and forms of the building is proposed (Fig. 1). To validate the method extensive public surveys (A and B) were carried out, which have been proved to be a good tool for visual assessment throughout bibliography (Stamps III and Nasar, 1997; Habron, 1998; Bishop *et al.,* 2004; Tilt *et al.,* 2007, etc). With the results were obtained some conclusions which can offer to engineers, architects, landscape designers and planners, objective design guidelines or criteria for a good integration of the buildings.

Methodology

Background

Line characteristics

Lines can be defined as a real or imaginary path that follows the vision line of the observer when abrupt differences in form, colour or texture are perceived. There are three kinds of lines (Español, 1995):

i) *Strip lines*: defined as two-dimensional forms of a lineal nature due to the contrast produced by two pseudo-parallel lines (in Fig. 2 the road is a strip line).

Figure 2. Different kinds of lines.

ii) *Border lines*: the frontier between two areas of different surface characteristics (colour or texture), which defines the contrast between them (for example, the eaves in Fig. 2).

iii) *Silhouette lines*: they generate an object in relation to a background. The skyline is the most singular silhouette line (in Fig. 2 the horizon and the vertical edges of facing walls are silhouette lines).

Any line has three characteristics that can be studied and measured to establish their interrelationships. The characteristics of the visual element line are (Español, 1995):

— *Sharpness*: is referred to the level of line definition. Intensity and continuity define sharpness. Silhouette lines tend to be sharper and to have, in general, greater definition than border lines. Sharp lines tend to dominate the poorly-defined or insinuated ones (Neufert, 1982; Español, 1995). Sharpness can be measured using two parameters: length and saturation. In this sense the length of the lines of a building in a natural setting offers no relevant information from a visual standpoint. That is, the straight lines of a building due to their simplicity are always sufficiently appreciable length compared with natural background (Montero-Parejo *et al.*, 2008). The sharpness on the border lines accentuates more the contrast than its length (Grossberg and Pessoa, 1998; Neuman *et al.*, 2007). There are exceptions such as cases of clear overcoming of the horizon, being more common in vertical orientations which are typically found in buildings in urban environments. In this sense, break the continuity of lines and simplicity of a rural building can be addressed with the introduction of vegetation in close-observation (Ikemy, 2005).

— *Complexity*: refers to simplicity, direction changes, kinks, breaks or undulations in the lines. Simple and continuous lines are more dominant than discontinuous and broken ones (Neufert, 1982; Español, 1995). Lines of natural landscapes are not usually straight. For this reason, buildings are mainly contrasted with countryside (Fig. 3).

— *Direction*: is the position of the line in relation to the horizontal dimension. It can be studied by measuring the line angle against the horizontal (Fig. 3). In visual perception the vertical dimension is dominant over all directions (Neufert, 1982; Español, 1995).

Form characteristics

Form is one of the most important features of any object. In this study it is defined as mass delimitated by object outlines, which is perceived as an entity in itself due to knowledge and experience. There are two kinds of forms (Español, 1995):

Figure 3. The lines of natural landscapes and a building.

— *Two-dimensional forms*: are defined by areas with high contrast in colour or texture as against other adjacent areas. These forms lead to two-dimensional outlines in the countryside. Two-dimensional forms are considered a particular case of strip lines (*e.g.* facades in Fig. 2).

— *Three-dimensional forms*: are those defined by volumes resulting from terrain topography, or due to the existence of isolated or grouped objects (*e.g.* global building in Fig. 3).

Just as line, form has three basic characteristics:

i) *Geometry*: related to form composition, varying from regular forms (square, sphere) to irregular patterns; regular shapes, with pure and simple patterns, are dominant in a scene.

ii) *Complexity*: is the degree of simplicity in any shape; visual perception is dominated by simple elements which are easily understandable (Neufert, 1982; Español, 1995).

iii) *Direction*: in relation to the horizontal landscape; attention of the observer is attracted more by vertical shapes, especially when reach and exceed the skyline (Neufert, 1982; Español, 1995).

Research methodology for studying lines and forms of buildings and the environment

Definitions of relationships between types of any characteristic

The relationship between two types of the same characteristic (Table 1) can be analyzed (García, 1998).

The evolution of the computer science allows measuring visual parameters easily, for example standard deviation of colours. This aptitude of comparing allows establishing relations among these visual elements and therefore relating representative elements of buildings to those which are representative and typical of the countryside, such as top edge or eaves of buildings and trees or skyline of the countryside. The different relationships between types of one characteristic are (García, 1998):

a) *Visual continuity* (VC): the relationship between two similar or neighbouring types in a diagram or scale. Buildings copy some values from their surroundings and reproduce features of the natural world which lends unity to the scene. The types of line and form characteristics are very similar for both the countryside and building. There is no change in the natural aesthetics of the scene. This means there is no diversity and there are no new contrasts in the scene. For instance, there are four ways to achieve VC: copying the natural element types (camouflage), copying the types of traditional buildings (architectonic imitation), building a natural screen that hides the project from view and selecting a hidden site.

b) *Diversity*: the relationship between two types separated by a certain distance. There is variation and, therefore, more diversity, which can enrich a scene. For instance, lines and forms building in Figure 3. In addition, through the method analysed in this article is possible identifying and differing:

— *Diversity without contrasts* (DWC): in this case there is an attempt to imitate the surrounding types whilst certain flexibility is allowed, thus investing the scene with variety. Diversity without contrasts is achieved by keeping to minimum the difference in contrast between the surroundings and the building.

— *Diversity with contrasts:* contrast is defined as the relationship between two types separated by a certain interval which is greater than a threshold value, *i.e.,* to an extent that they are perceived as being very different (Orland *et al.*, 1994). These contrasts can break up an unity of scene and consequently its compatibility, giving rise to incompatible contrasts. The Gestaltists (Arnheim, 1962) turned their attention to this and called these opposite visual states «sharpening». Sharpening is defined as an increase or exaggeration (to the point of poorly compatible contrast), and is used, for example, in urban signposting (Arnheim, 1962). This takes place when the different types making up the lines and forms of the new project are different to those that already exist. Contrast is essential in control of visual effects and perception (Langer, 1953). It is vital for clarifying of content and communication (Langer, 1953). The contrast between surroundings and building can be compatible or poorly compatible (García, 1998):

i) *Compatible contrasts* (CC): creation of suitable contrasts is one of the most important aspects of scenery quality; the value of the landscape increases when these contrasts are compatible and create unity in the scene.

ii) *Poorly compatible contrasts* (PCC): the design of guidelines or criteria must have three characteristics: it must be effective, suitable and feasible. This is hard to bring about when an innovative touch leads to the building cl*ashing with the natural countrys*ide.

Methodological proposal for quantifying relationships between types of any characteristic

Considering these relationships between types of any characteristic (VC, DWC, CC, PCC) and characteristics posed for lines and forms (Table 1), a quantitative method is developed to assess these visual relationships among building characteristics of lines and forms and the landscape ones (Fig. 4). This Figure 4 must be used in the following manner:

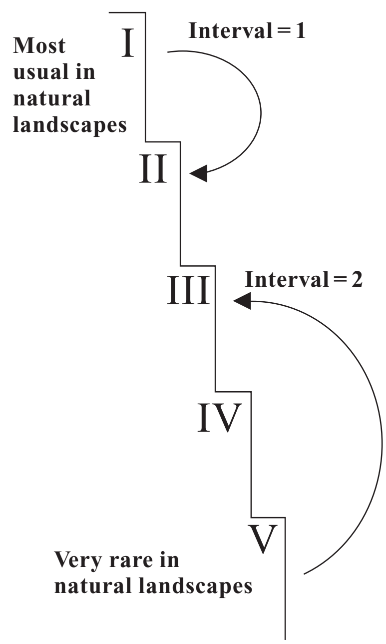
1. Obtain the Type (I, II, III, IV or V) of one line or form characteristic (sharpness, complexity, direction or geometry). The column named «Parameters» shows the method:

a) Sharpness of one line: according to the standard deviations of colours, by means of photographic treatment. In this sense, Photoshop® has been the software chosen for the current research. This software has also been widely used in other works related to visual perception and landscape integration (Karjalainen and Komulainen, 1999; Bishop, 2002; Ribe, 2005). For instance, the boundary lines of a building could be define like sharp lines (Type III) if one of the standard deviations of the colour canals between the building and the background is higher than 40 pixels or the percentage of saturation of boundary lines color is upper than 25%.

b) Complexity of one line or one form: according to the percentage that is broken or covered by the vegetation. As justified above, the simple lines of the building and by extension their geometry or shape, are easily visible against the background. In this regard to pass from V types (without vegetation and appreciable

		TYPE	NAME	PARAMETERS	
LINES	SHARPNESS			Saturation (%)	**Standard deviation of colours (0-255, Adobe Photoshop)** Standard deviation of red (σ_R), green (σ_G) and blue (σ_B). Only must be used if the line is defined by two areas in contact
		I	Insinuated	< 10	max [σ_R, σ_G, σ_B] < 25
		II	Medium	10 - 25	25 < max [σ_R, σ_G, σ_B] < 40
		III	Sharp	> 25	max [σ_R, σ_G, σ_B] > 40
LINES AND FORMS	COMPLEXITY			**Percentage that is broken or covered by the vegetation (%)**	
		I	Complex	> 80	
		II		60 – 80	
		III	Medium	40 - 60	
		IV		20 – 40	
		V	Simple	< 20	
	DIRECTION			**Relative angle to the horizontal (°)**	
		I	Horizontal	0 – 5	
		II	Oblique	5 - 80	
		III	Vertical	80 - 90	
FORMS	GEOMETRY			**Percentage that is covered by the vegetation (%)**	
		I	Irregular	> 80	
		II		60 – 80	
		III	Medium	40 - 60	
		IV		20 – 40	
		V	Regular	< 20	

RELATIONSHIPS



Interval = 0	VISUAL CONTINUITY
Interval = 1	DIVERSITY WITHOUT CONTRAST
1 > Interval > 4	COMPATIBLE CONTRAST
Interval = 4	POORLY COMPATIBLE CONTRAST

Figure 4. Sharpness, complexity, direction and geometry relationship.

whole building in all its simplicity) to more complex and integrated types (I and II), vegetation ranges are introduced to decrease the simplicity, breaking the vision of continuous lines and shapes.

c) Direction of one line or one form: according to the relative angle to the horizontal. In this respect, rural buildings usually have a predominance of horizontal lines (type I), generally consistent with environment.

d) Geometry of one form: according to the percentage that is covered by the vegetation, as it was also discussed in point 1b. The geometry of a building is well known for standing out for having a more regular basis than the natural environment. In this sense, softening this integration is also addressed by using vegetation to break the geometry of the whole.

2. Define the relationship for two types of the same characteristic for two lines or two forms. The method is showed in the last column of the figure (Relationships):

a) The types named I and II are the most usual in natural landscapes. Thus, IV and V are very rare or uncommon in these ones (Español, 1995)

b) According to the value of the parameter named «Interval» (jump from one type to another) the relationship could be VC, DWC, CC or PCC. When the interval value is equal to 0, the lines or forms building types are similar to the countryside ones (VC). Lines or forms building types are known as discordant (PCC) only when that value is equal to 4 (maximum difference).

Finally, with the current method (Fig. 4) and the explanations given above, the proposed measure of impact can be summarized assuming that the degree of sharpness of the entire building (understood through the lines of its whole geometry) and the quantity of it that

Table 2. Summary chart of relationships between buildings and surroundings lines and forms. Numeric sub-indexes (DWC_x, CC*x*) only indicate the position on the chart regarding the crosses and taking into account the percentage of building covered by vegetation

Dominant of line sharpness	Percentage of building covered by vegetation (%)			
	> 80	80-60	60-20	< 20
Insinuated	VC	DWC_1	CC_2	PCC
Intermediate	DWC_0	DWC_1	CC_2	PCC
Sharp	CC_0	CC_1	CC_2	PCC

The aims of this notation is try to achieve, in a subsequent analysis, if the degree of vegetation is object of further study in for example the same sharpness conditions. Thus, x = 0 means maximum percentage of vegetation (> 80%), x = 1 means a percentage between 80-60% of the building is covered by vegetation and x = 2 indicates a vegetal screen in front of the building covering the house between a 20-60%. PCC cases are not followed by any sub-indexes; they are considered the worst situations in which there is not vegetation covering building facades.

is covered by vegetation, are the most important factors in the integration of its silhouette line. The direction, mostly horizontal of lines and forms of rural building, does not introduce a significant impact (Type I or II) as discussed in paragraph 1c. In Table 2 is attached a summary chart that can help the understanding of the proposed method. It could be interpreted as a simplification of the Figure 4.

Summary application tables for relating the lines and forms of the building with the environment ones

This methodology (Fig. 4 and Table 2) can be implemented with tables that appear in Figures 5 and 6. These figures must be completed in the following way:

1. Determine the important construction elements of the building (cursive in table) that will be used to establish interrelationships with the surroundings.

— The choice of these elements depends upon their dominance in the scene, usually top and sloping edges are the main lines of the building [*e.g.* Fig. 5, top edge (A) and sloping edges (B)]. If other element was considered important it can be added (cursive). For this reason, these figures can be completed by any person with a minimal aesthetic and technical formation, capable of interpreting the relevancy of visual elements in a scene.

— Define the kind of lines (strip «Strip», silhouette «Sil», border «Bor») or forms (two-dimensional «Two» or three-dimensional «Thr»), their sharpness, complexity, direction and geometry (Fig. 4).

2. Select the important elements of the environment (cursive in table). The choice of these elements depends upon their dominance in the scene, usually skyline and trees or walls of neighbouring buildings etc. These elements are considered the most essential to the designer due to their importance, relevance or size in the environment [*e.g.* Fig. 5, trees (1) and skyline (2)].

3. Relate the lines and forms of the building with the environment ones.

— VC, Diversity and Contrast studies must be studied with area pairs (Fig. 4). The indicated elements of the building can then be related to all those of the environment. For instance, in Figure 5 four pairs of elements have been considered (A1, A2, B1 and B2).

— Establish the qualifier (VC, DWC, CC or PCC) for the different pairs (important elements building-surroundings) and for each characteristic. This qualifier is obtained using the table of Figure 4 that is an approaching to define the sharpness, complexity, direction and geometry relationships. For instance, in Figure 5 the qualifier for defining the complexity in pair A1 is PCC because the interval between the Top edge (A, type I) and the Trees (1, type V) is equal to 4.

— Define the value of each qualifier (VC, DWC, CC and PCC) in the scene. All obtained values through the different pairs are recorded. The V_{max} (maximum value) is the largest number of all those recorded for VC (V_{max}VC), DWC (V_{max}DWC), CC (V_{max}CC) and (V_{max}PCC).

— Obtain the final evaluation. The conditions that will lead to PCC, CC, DWC and VC must be considered (*e.g.* Fig. 6, PCC). The final evaluation of lines and forms is the worst value of Figures 5 (lines) and 6 (forms). The philosophy of this final evaluation is preserving natural landscape and protecting it from discordant elements (García, 1998).

4. The chart is complemented with notes that the designer considers appropriate such as the conditions in which the photographs were taken. For instance, some atmospheric conditions as pollution, mist, fog and rain increase the effect of distance and intense illumination reduces it (Español, 1995).

Assessment of the surveys

For obtaining objective design guidelines, the relation between this final evaluation (PCC, CC, DWC or

LINES														**Ref.:**
	Kind			**Sharpness**			**Complexity**					**Direction**		
	Strip	Sil.	Bor.	I	II	III	I	II	III	IV	V	I	II	III
BUILDINGS														
Roof														
A. Top edges		√				√					√	√		
B. Sloping edges		√			√					√			√	
C. Eaves														
Facing walls														
D. Vertical edge														
E. Carpentry														
Others														
F.														
G.														

Determine the characteristics of the important construction elements (italics) in order to establish relationships

SURROUNDINGS	Strip	Sil.	Bor.	I	II	III	I	II	III	IV	V	I	II	III
1. Trees			√	√			√						√	
2. Skyline		√				√			√				√	
3.														
4.														
5.														

Determine the characteristics of the important elements in the environment and indicate (italics) those which establish relationships with the building

RELATIONSHIP TYPE	$V_{máx.}$											
Poorly Compatible Contrasts PCC	1					~~1~~A1	2	3	+			
Compatible Contrasts CC	2	~~1~~A1	2	3	+	~~1~~A2	~~2~~B1	3	+	1	2	+
Diversity Without Contrasts DWC	2	~~1~~B1	~~2~~B2	3	+	~~1~~B2	2	3	+	~~1~~A1	~~2~~A2	+
Visual Continuity VC	2	~~1~~A2	2	3	+	1	2	3	+	~~1~~B1	~~2~~B2	+

FINAL EVALUATION

If $V_{máx.}PCC \geq 1$	**POORLY COMPATIBLE CONTRASTS √**
If $V_{máx.}PCC = 0$ and $V_{máx.}CC \geq 1$	COMPATIBLE CONTRASTS □
If $V_{máx.}PCC = V_{máx.}CC = 0$ and $V_{máx.}DWC \geq 1$	DIVERSITY WITHOUT CONT. □
Remainder	VISUAL CONTINUITY □

The qualifiers of the different pairs established between the important elements (building-surroundings) for each characteristic appear in the corresponding line. Only a final value is obtained which considers the previous conditions

NOTES

- Line study of this building in this landscape
- The roof (top edge and eaves) provides PCC to the surroundings.
- This photograph showed good assessments, although vegetation as a change element was significantly more chosen (61 %) in this photo than in VC photo (16%, figure 10).

Figure 5. Example of the lines study.

VC) and the valuations of the integration must be studied. For this reason, in a first approach, a perception survey was made (Survey A, Table 3) using 30 photographs of buildings (*e.g.* Fig. 3), many of which were computer simulations (Danahy and Wright, 1988; Bishop and Leahy, 1989; Bishop and Hull, 1991). These were shown to 150 people drawn from different age-groups, educational backgrounds and locations. The questionnaire allowed multiple answers and blank answers were not accepted. The first objective was to

FORMS **Ref.:**

		Kind		Geometry					Complexity					Direction		
		Two	Thr	I	II	III	IV	V	I	II	III	IV	V	I	II	III
BUILDINGS	Tridimensional															
	A. Global building		√					√					√			√
	B. Salient															
	D. Roof plane															
	E. Facing wall															
	F. Carpentry															
	Others															
	G.															
	H.															

Determine the characteristics of the important construction elements (italics) in order to establish relationships

		Two	Thr	I	II	III	IV	V	I	II	III	IV	V	I	II	III
SURROUNDINGS	*1. Trees*		√	√					√							√
	2.															
	3.															
	4.															
	5.															

Determine the characteristics of the important elements in the environment and indicate (italics) those which establish relationships with the building

RELATIONSHIP	TYPE	$V_{máx.}$											
	Poorly Compatible Cont. PCC	1	~~1~~ A1	2	3	+	~~1~~ A1	2	3	+			
	Compatible Contrasts CC	0	1	2	3	+	1	2	3	+	1	2	+
	Diversity Without Cont. DWC	0	1	2	3	+	1	2	3	+	1	2	+
	Visual Continuity VC	1	1	2	3	+	1	2	3	+	~~1~~ A1	2	+

FINAL EVALUATION	If $V_{máx.}$PCC ≥ 1	**POORLY COMPATIBLE CONTRASTS** √
	If $V_{máx.}$PCC = 0 and $V_{máx.}$CC ≥ 1	COMPATIBLE CONTRASTS □
	If $V_{máx.}$PCC = $V_{máx.}$CC = 0 and $V_{máx.}$DWC ≥ 1	DIVERSITY WITHOUT CONTRASTS □
	Remainder	VISUAL CONTINUITY □

The qualifiers of the different pairs established between the important elements (building-surroundings) for each characteristic appear in the corresponding line. Only a final value is obtained which considers the previous conditions

NOTES

- Form study of this building in this landscape
- Regular geometry of the building provides PCC to the surroundings.
- This photograph showed good assessments, although vegetation as a change element was significantly more chosen (61%) in this photo than in VC photo (16%).

Figure 6. Example of the forms study.

establish a hierarchy among visual elements (USDA Forest Service, 1974; Smardon, 1979; Español, 1995; Table 1) and to explore preference criteria of people (Kaplan and Kaplan, 1989).

In this context, colours could be affecting line and form of building integration (Cañas *et al.*, 1996). Thus, in a second survey the aims were to control the possible influences in lines and forms integration of colour sur-

Table 3. Questions posed in Public Surveys A and B

	Public Survey A				
1	How would you rate the integration of the building(s) in the scene in this photograph?				
	Very bad	Bad	Acceptable	Good	Very good
2	What characteristic(s) of the group of buildings or their construction components would have to be modified to improve their integration in the scene in this photograph?				
	Colour	Texture of the materials	Lines and forms	Scale	Spatial location
	Public Survey B				
1	How would you rate the integration of the building(s) in the scene in this photograph?				
	Very bad	Bad	Acceptable	Good	Very good
2	What, from the list below, would you change in order to improve building integration?				
	Building size	Building colours	Building materials	Vegetation around the building	Nothing

face properties and to try to find out if the relationships among buildings and surroundings of lines and forms (*e.g.* PCC or CC) depend on colour. In addition, the results could also validate or reinforce the obtained results in survey A.

Thus, buildings with appropriate and inappropriate colours were shown to achieve an integration with a high probability of being classed as «Good-Very Good» or «Bad-Very Bad» respectively (Garcia *et al.*, 2003). Moreover, the role of vegetation as a filter is directly related to lines and forms in the proposal method (Fig. 4). For this reason, the creation of a new experiment that fixed initial colours and design, combining different degrees of filtering by vegetation, could be led to clarify how the integration of lines and forms is evaluated by people.

In this sense, 16 photographs were used in this survey B. Four original cases were taken from an experimental area of inland Spain and were modified to reach different types of lines and forms according to the methodology (4 original cases × 4 modified scenarios). This number of cases is statistically consistent to develop the study (Moore, 1995). In this way, there are PCC cases (there is no vegetation covering building geometry), CC cases or DWC ones [there is a high percentage of vegetation (20-80%) softening the building geometry without hiding the project totally (Fig. 4)]. Besides, neither its original colours nor materials were changed in the original photos in order to isolate the interaction between colour and degree of filtering.

Two questions were posed (Table 3) for every photo. Each interviewee was requested to choose only one option per question and blank answers were not accepted. Photos were shown at random and minimum size was high enough to distinguish building details (10 × 15 cm). This public survey was shown to 106 people chosen between different age groups, educational backgrounds and locations; 5,088 answers were received. These were considered sufficient for obtaining meaningful results. Moreover, statistical techniques based on chi-square test like frequency bars and/or contingency tables, were chosen for the subsequent analysis of data. These techniques are typical analysis in opinion or social research studies (Díaz de Rada, 2002) and with ordinal and nominal variables which do not follow a normal distribution like the case study.

Finally, in both surveys, photos were taken from a nearby rural road, in sunny days and at midday, trying to avoid negative effects of distances and adverse climatic conditions (Bishop, 2002).

Results

The answers to the first question in survey A (Fig. 7), show the correlations between integration values and relationships between elements obtained by tables similar to those of the Figures 5 and 6. Thus, in integrations classed as «Good» or «Very Good», there were no PCC. Integrations classed as «Acceptable» showed CC, DWC and VC. In these cases, CC has the greatest weight. However, in the integrations classed as «Good» or «Very Good», VC was the most important. CC integrates buildings and also increases the quality

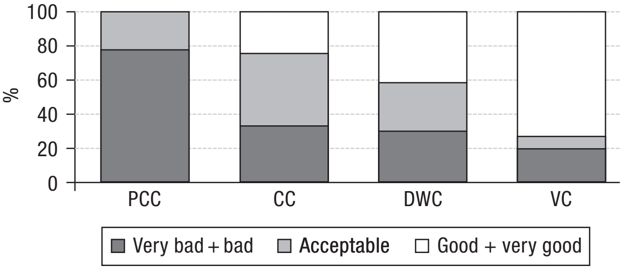


Figure 7. Answers to the first question of the survey A.

of a scene. Nevertheless, not all designers have the necessary aesthetic knowledge or ability to design things with this in mind.

On the other side, these answers show the importance of designing without sharp lines. For example, in the Figure 8 the line that is defined by the roof and wall has: $\sigma_R = 32$ pixels, $\sigma_G = 93$ pixels and $\sigma_B = 90$ pixels, then max $\{\sigma_R, \sigma_G, \sigma_B\} > 40$ (Type III → Sharp Line). These buildings break the skyline and define silhouette lines. However, they have different sharpness values. In Survey A, 35% of people (the highest value of the survey) said that lines and forms should be changed. Figure 9 shows the importance of avoiding simple and regular construction elements. This figure presents type V and 67% of people (the highest value) classed the integration as Bad or Very Bad and 33% changed lines and forms. Also these answers show the importance of not breaking the skyline. For example in the Figure 10, the real image is Figure 10a and the integration values (Very Bad, Bad, Acceptable, Good and Very Good) are better if the skyline is not broken (Fig. 10b).

The answers to the second question in survey A show the importance of visual elements on buildings

Figure 8. Example about the importance of designing without sharp lines.

Figure 9. Example about the importance of avoiding simple and regular constructions elements.

integration. It is obtained the average percentage of occasions on which the visual element was identified as requiring modification: Colour 35%, Spatial Location 27%, Lines and Forms 19%, Texture 18% and Scale 16%. It is remarkable the importance that has colour element.

Regarding to survey B, statistical results for lines and forms analysis in building examples with appropriate colour (*e.g.* Fig. 11a) showed a behaviour of PCC photos which significant differences from DWC and CC cases (in both questions $\chi^2 < 0.05$). In general, buildings with a suitable colour scored good assessments by interviewees (Acceptable, Good or Very Good), whatever the degree of vegetation that was filtering facades (Fig. 12a). However PCC were the least well-rated photos, suggesting that vegetation around house improves the valuation that people have about building integration [Fig. 12a, results from the first question posed (Table 3)]. Additionally, vegetation as an element of change was chosen significantly more in PCC photos than in the other ones [Fig. 12b, results from the second question posed (Table 3)].

On the other hand, statistical results of analysis of lines and forms in building examples with inappropriate colour (*e.g.* Fig. 11b) showed that PCC photo assessment differed significantly from CC_1 and CC_2 cases (only in the first question $\chi^2 < 0.05$). These differences are not significant between photos in the second question ($\chi^2 > 0.05$). The buildings with inappropriate colours showed important levels of bad assessment by interviewees (Bad or Very Bad), especially when there was no vegetation to filter facades [PCC, Fig. 13a, results from the first question posed [(Table 3)]. However, CC_1 were the least badly-rated photos of the three cases, suggesting that vegetation around the

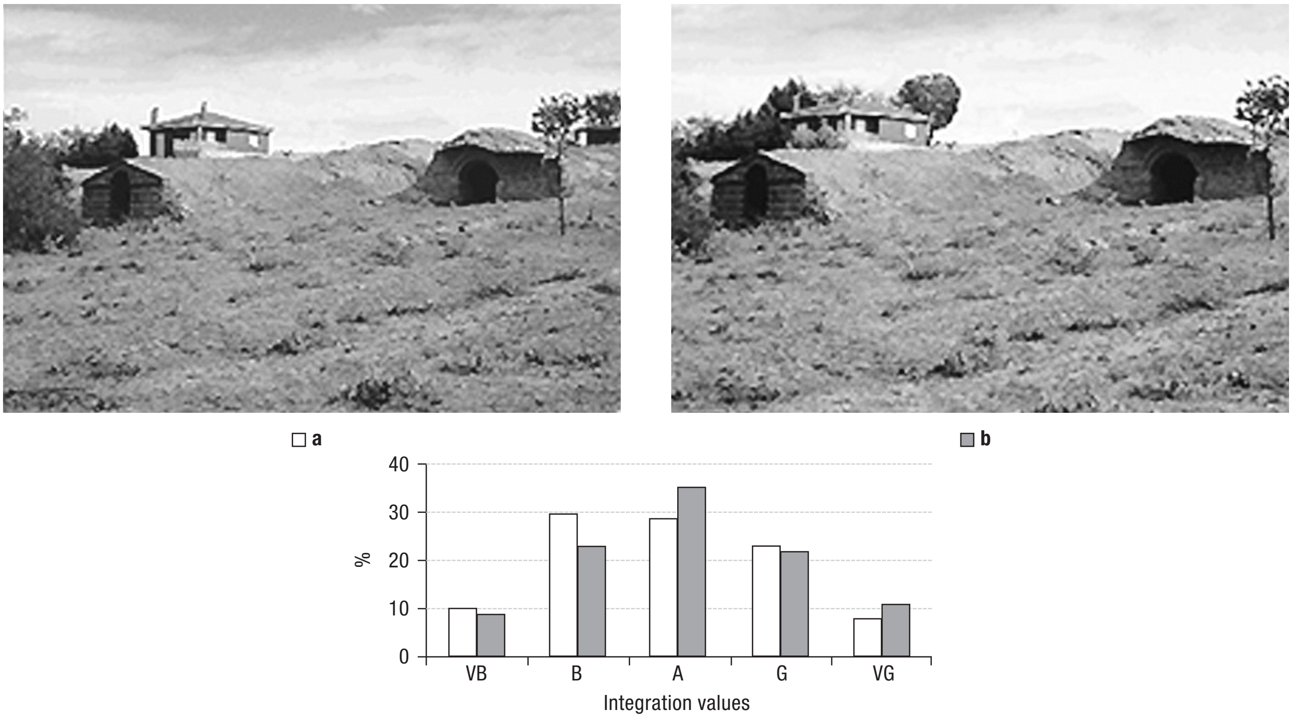


Figure 10. Example about the importance of not breaking the skyline.

house further improves how people evaluate building integration. However, vegetation as an element of change was not chosen significantly more in any case [Fig. 13b, results from the second question posed (Table 3)].

Discussion

The most of the images posed in the surveys were simulations made with Computer Aided Design and Photographic Treatment. The result has been good be-

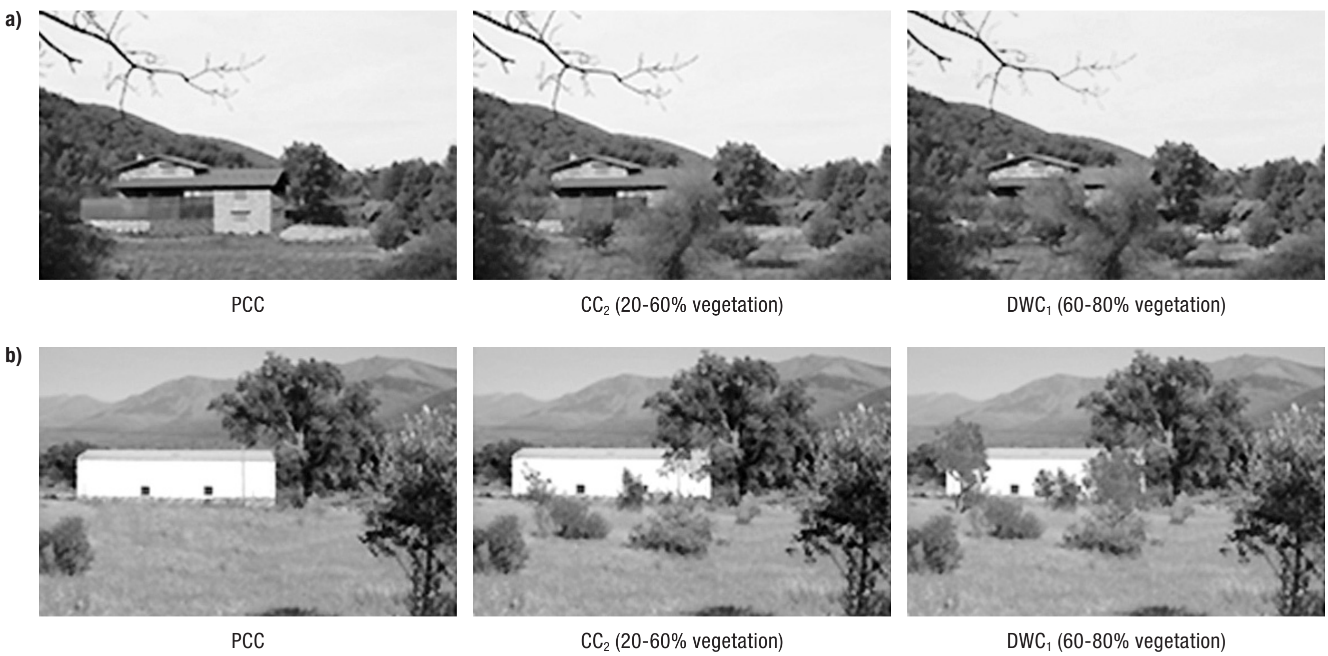


Figure 11. Examples of photos for lines and forms elements in survey B.

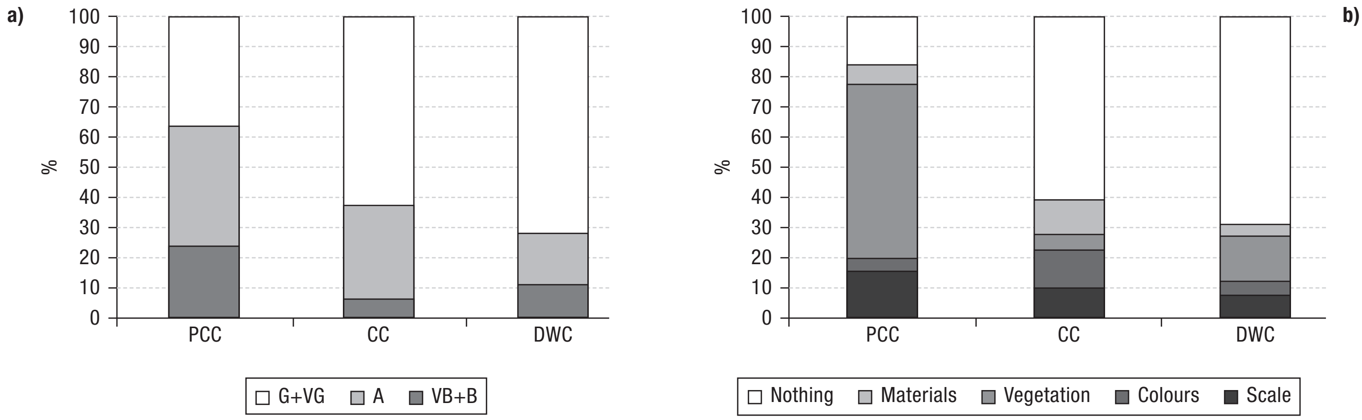


Figure 12. Statistical results for lines and forms analysis in building examples with appropriate colour (Survey B, *e.g.* Fig. 11a): a) Results for first question posed in survey B (Table 3). b) Results for second question posed in survey B (Table 3).

cause people did not know which were the real images and which the simulated ones. It is easy with these tools to create new alternative designs. The next step is to study these scenes in movement. Perhaps augmented reality could facilitate this process.

On the other side, the introduction of new types into a scene (*i.e.* Figs. 3 and 5) can be generated by using characteristics that define lines and forms: sharpness, complexity, direction and geometry (Fig. 4). It should be noted that these line and form characteristics can be decisive factors in the integration of buildings into the scene; mainly the complexity and the geometry are important and differentiate the building from its surroundings. For example:

— VC: The highest probability of achieving an integration class as «Good» or «Very Good». Closed colours among surfaces that define building outlines, thus insinuated lines (low sharpness) are obtained. It can improve integration but it is necessary to choose a site covered or filtered by vegetation (Table 2). Thus, the role of vegetation as a filter is directly related to lines and forms. The use of natural screens can soften building geometry and gives continuity from the construction to the environment (Smardon, 1988; Ikemy, 2005). Unfortunately this is not always possible.

— PCC: The highest probability of achieving an integration class as «Bad» or «Very Bad». In the case of lines and forms, the absence of vegetation in the surroundings means that the whole of the project can be seen (Figs. 8 and 9). In practice, this is the most striking situation. In this case, sharpness of lines has no influence on the kind of impact (Table 2).

According to these studies, some guidelines are proposed:

i) *Choosing closed colours between surfaces that define building outlines.* It generates insinuating lines. Sharp contrast which may be poorly compatible must be avoided (Fig. 8). In this sense, despite the fact that

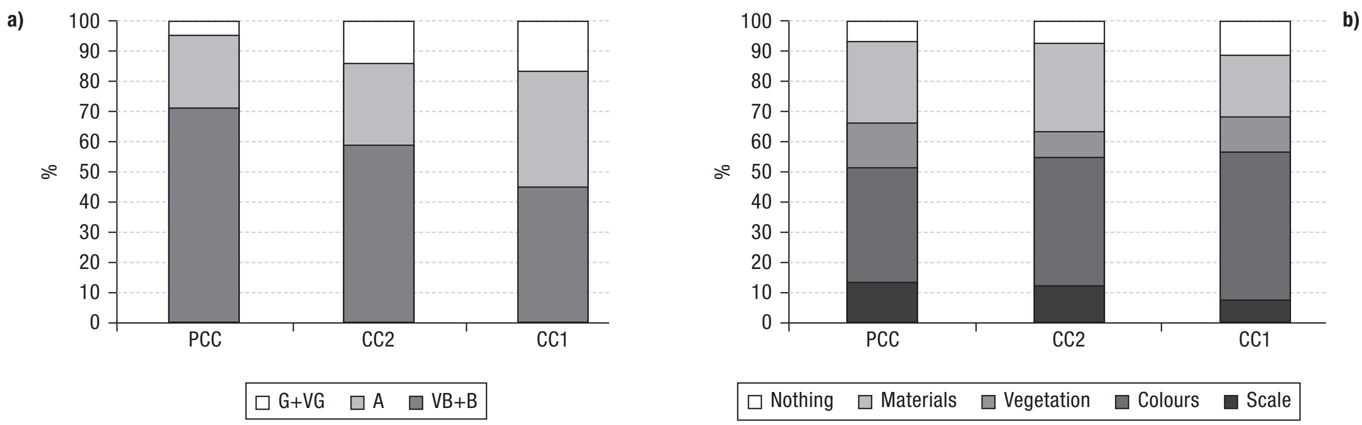


Figure 13. Statistical results for lines and forms analysis in building examples with inappropriate colour (Survey B, *e.g.* Fig. 11b): a) Results for first question posed in survey B (Table 3). b) Results for second question posed in survey B (Table 3).

the current method (Table 2) does not differentiate different cases of PCC from the point of view of visual impact, must be underlined the fact that people's appreciation of building integration is not equal in different cases of PCC. For example, when a building is not covered by vegetation (PCC) and has insinuated or intermediate-value lines, it obtains better punctuation (Fig. 12a, PCC case) than others in similar conditions but with sharp lines (Fig. 13a, PCC case). To study these facts in more detail, this research is currently focusing on analyzing a possible gradation in PCC_x cases.

ii) *Breaking or partially covering lines and forms with vegetation*.

— *Avoid excessive regularity and simplicity*. Simple and regular forms and straight lines are uncommon in natural landscapes. Therefore, these types of buildings attract more human attention and can generate PCC (Fig. 9). The use of vegetation softens building geometry and gives continuity from the construction to the environment. In spite of line sharpness, when vegetation is used (> 20%) at least CC can be reached (Fig. 4 and Table 2). Results from survey B, showed that this level is sufficient to attain acceptable values of building integration (Fig. 13a CC_x cases). So, it is always interesting to use vegetation but especially if building colours cannot be changed. Furthermore, whenever there is any percentage of vegetation upper than 20% and the building has sharp lines, the relationship between buildings and surroundings elements is always CC, whatever the covered percentage, the house is always recognizable through the vegetation (Table 2, CC_0, CC_1 or CC_2 cases). In these sense, some light differences were found between CC_1 and CC_2 cases (Fig. 13a CC_x cases). CC_1 (more percentage of building covered by vegetation) is slightly better rated than CC_2 (less percentage of building covered by vegetation). The same could occur if a covered percentage between 20-60% is used in front of the same house, and building lines were changed for the best to the worst sharpness (CC_2 cases in Table 2). These facts must be also analyzed in depth in a future work.

— *Use insinuating lines.* If suitable colours are used as well as vegetation cover, the best integration is attained (Table 2 and Fig. 12a, DWC and VC cases).

iii) *Do not break skyline.* Vertical shapes draw more attention to themselves (Neufert, 1982; Español, 1995), especially when shapes reach and exceed skyline (Fig. 10).

As a result, objective design guidelines are obtained. It is possible to make an evaluation of the different alternatives available and to select the most suitable according to the type of integration sought. One of the main conclusions of this study is that relationships between different types of visual characteristics are satisfactory for the study of integration quality (Fig. 4). Relevant correlations were obtained between integration appraisal and VC, DWC, CC and CPC (Fig. 7).

It is usual that aesthetic knowledge does not exist and the only help of the designer is his/her intuition, then VC must be used according to the guidelines proposed in this study. Thus, there will be a greater probability that integration is qualified as «Good» or «Very good» (Fig. 7). For achieving it the vegetation is a very useful tool, because filtering the building with it breaks regular geometries and simple lines and it has a clear positive effect in its landscape integration (Fig. 12). Colour is the element most chosen to be changed, even in those designs in which colours of the facades are badly perceived but still the annoying effect of colour remains (Fig. 13). In any case, the best building solution is one that combines both: a suitable colour and enough degree of filtering.

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