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# Aesthetic and Visual Impact Assessment of a Quarry Expansion

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*Abstract*: Little research devoted to examine how quarry rehabilitation projects may incorporate aesthetics to improve their public acceptance. In the present study it will developed a visual impact assessment with the use of geographic information systems and computer simulations. In this approach, landscape evaluated with respect to a combination of abstract design parameters deemed relevant to landscape aesthetics. The primary functions of the visual impact assessment were to identify key viewpoints from which the quarry will be visible. Numerical values used to assign factors such as slope, vegetation, observation distance, visual magnitude and human activities in order to analyze and evaluate the landscape. A numerical rating was assigned indicating low, moderate, or high visual absorption capability.

*Keywords:* landscape, reclamation, quarry, aesthetic, geographic information system

## 1 Introduction

The aesthetics, a western concept, is a matter largely discussed. It has been a subject of debate for philosophers, artists, since at least the time of Socrates and more recently, for environmental managers/policy makers [12]. Aesthetic expectations ought to be considered in a thoughtful design. To achieve this, is needed a careful understanding of visual and non-visual environmental aesthetics, knowing that colour, form, line and texture are characteristics that define visual and aesthetic any object or landscape [10]. Some authors tend to associate aesthetic experience with a purely sensuous, non-cognitive response to visual stimuli [6]. Other thinkers see aesthetics as an enhancement of cognitive powers only achieved through the reciprocity of sensible form [7], another believe that some aesthetic properties may not be perceptual [5].

Limestone quarries are often located in areas of high scenic value, sometimes lying within National Parks. It is inevitable, that the visual impact of quarrying receives considerable attention - particularly in view of the long duration of quarrying activities and often permanent re-profiling of the landform. Public opposition against quarrying activity it's a common and day-to-day phenomenon [11]. Nonetheless, little research has been devoted to examine how aesthetics may be incorporated in quarry rehabilitation projects to improve their public acceptance.

Visual impact assessment is often regarded as a subjective process [2, 3, 14]. However, techniques which ensure that investigations can be undertaken in a systematic, consistent mode, were developed making the assessment as objective as possible [9] and has been dominant in environmental management practice [4, 8, 13]. In this approach, landscape evaluated and inspected with respect to a combination of abstract design parameters deemed relevant to landscape aesthetics. The main aim of the present work was to use an expert/design approach, geographic information systems and computer simulations to evaluate landscape quality, sensitivity and visual absorption capability of a limestone quarry in Portugal.

## 2 Materials and methods

The primary functions of the visual impact assessment were to identify landscape units and key

viewpoints from which the quarry will be visible; to evaluate the sensitivity of these critical viewpoints; to assess the impact of visibility; and to modify the quarry design in such a way as to reduce potential impact to a minimum. The visual impact assessment was conducted exploiting the means of travel used by the average visitor or traveller (car, bicycle or on foot). The location of key viewpoints identified on the field with a Global Positioning System (GPS).

Using aerial photos and in situ observations the landscape of the quarry surrounding area divided into four units: A) quarry industrial area; B) other industrial area; C) forest; D) agriculture.

Numerical values used to assign factors such as slope, vegetation, observation distance, visual magnitude and human activities in order to analyze, evaluate and characterize the landscape. A numerical rating assigned indicating low (1), moderate (2), or high (3) visual sensitivity and quality. The development of more than one design option for each proposed operation may make the design and visual impact assessment process more efficient and cost effective. Consequently, it was prepared three design options: sketching, photographic manipulation and computer simulation.

A Digital Terrain Model (DTM) generated with ArcGIS8.3 from digitised contour maps [1]. In order to evaluate conditions in year 2034, at the completion of the quarry, the DTM was modified with the final quarry contours. From the final DTM was studied the potential intervisibility of the area and the two-dimensional maps of all areas visible from the viewpoints at a given height (viewshed) of the proposed quarry expansion. A viewshed is the two-dimensional map of all areas visible from a given point at a given height.

## 3. Results and discussion

Visual quality for each of the landscape units is shown in Table 1. The quarry and other industrial and commercial area present low quality according to the used parameters and forest and agricultural landscape units present medium quality.

Landscape sensitivity or fragility for each of the landscape units is shown in Table 2. According the above classification the most fragile landscape unit was quarry area while the other present medium sensitivity. A landscape with low visual sensitivity rating can absorb a lot of change without loosing its quality [15]. According to the above, any change in the quarry area will be immediately visible and effective, so visual mitigation measures should accompany the development of quarry. Visual barriers to the highway A1 with fast growing trees are suggested.

Table 1 – Landscape quality for each landscape unit.

| Parameters | | Landscape Units A | B | C | D |
|---|---|---|---|---|---|
| Morphology | Slope | 3 | 1 | 2 | 1 |
| | Complexity | 1 | 1 | 2 | 2 |
| Vegetation - land use | Diversity | 1 | 1 | 2 | 2 |
| | Fragmentation | 1 | 1 | 2 | 2 |
| Water | Presence | 0 | 0 | 0 | 1 |
| Quality | Mean | 1 | 1 | 2 | 2 |

A) quarry; B) other industrial area; C) forest; D) agriculture

There were two primary populations of viewers: viewers from households and travellers of the highway A1. Viewshed analysis of the quarry expansion project showed what areas of the disturbed surface observers, for any visible position, can see and how many observers can see the position. Only 10% of the quarry will be visible from the nearby village and from a 2000 meters distance.

Table 2 – Landscape fragility for each landscape unit.

| Parameters | Landscape Units A | B | C | D |
|---|---|---|---|---|
| Vegetation | 0 | 0 | 2 | 3 |
| Slope | 3 | 1 | 2 | 1 |
| Topography | 3 | 1 | 2 | 1 |
| Form/size of viewshed | 3 | 2 | 2 | 2 |
| Viewshed complexity | 3 | 1 | 1 | 2 |
| Fragility | 3 | 2 | 2 | 2 |

A) quarry; B) other industrial area; C) forest; D) agriculture

Figure 1 shows the quarry and the visible portion of the area from one observation point that considered key viewpoint. For this observation point was used $80^{o}$ visibility angle and 2000 meters maximum distance considered sufficient. Travellers from highway A1 will also view the quarry as they drive through the valley. From field survey was recorded that 3600 meters of highway are visible from the quarry and with a travelling speed of 120km/h the quarry will be visible for relatively short period. Forty seconds was the longest viewing time at close range (1400 meters were visible in the 1000 meter buffer). However, less than 50% of the

quarry would be visible from any point of the highway. Furthermore, travellers going from South to North would view only an insignificant area of the quarry, while the others travelling the opposite direction will experience the highest visual impact.

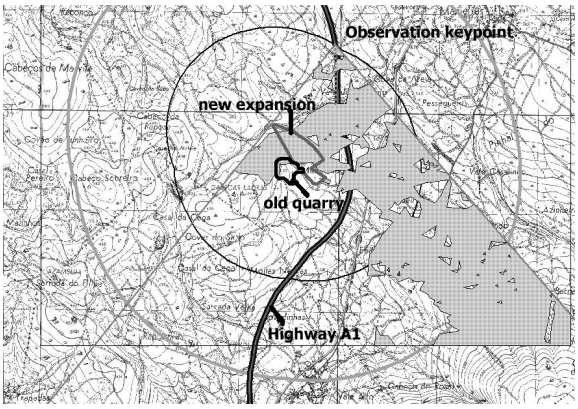


Figure 1. Map of the quarry study area. The shadowed area is showing the visible portion of it from one observation point of the Highway A1.

Finally, aerial photographs wereoverlaid on the DTM to simulate a realistic view of the quarry area at the end of life (year 2034). Various digital fly-over videos were generated to simulate in a realistic way the appearance of the proposed expansion (figure 2).


Figure 2. Fly-over digital video from a 3D scene aimed to visualize the quarry at year 2034.

The ArcviewGIS 3D Analyst extension used to generate three-dimensional views of the actual and completed ground surfaces. The fly-over video created after a digitalisation of a path in a 2D map display and then traversed in the 3D scene. However, the 3D extension of Arcview was permitting to navigate freely in 3D space and to relate representations in 2D maps with 3D scenes synchronizing user interaction with the database model.

**4. Conclusions**

The aesthetic study helped to assess visual impacts of limestone quarrying. Highway A1 users are the most affected, while residents will have minimum visibility to the quarry. Landscape quality of the quarry was very low and will not decrease due to mining activity. Fragility of the quarry area was high and can not absorb a lot of change without loosing its quality. Computer simulations such as photomontages and digital fly-over videos helped in three-dimensional imaging and characterization of the landscape. Visual mitigation measures should accompany the development of the quarry like visual barriers to the highway A1 with fast growing trees and permanent irrigation.

The presented evaluation method could help governmental officials to take the appropriate decision: accept, reject or suggest aesthetical modifications in any proposed quarry project. The presented aesthetic study may help to minimize visual impacts of quarrying or other development projects in Mediterranean forest landscapes.

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