

Slope reinforced  
with

**Fortrac®** geogrid

**Slope structure supporting the construction area of the McDonald's drive-in restaurant at Agadir**



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**Initial project**

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The Moroccan developer for McDonald's restaurants has employed a local engineering design office to prepare the construction plans for McDonald's drive-in restaurant in Agadir.

The site slopes steeply and the main access road, Bd. Mohammed V, is 5.50 m higher than the rear boundary of the site. The design of a McDonald's drive-in requires a site on a level with the access road.

To achieve this, the local office had designed a traditional peripheral reinforced concrete wall to form the slope retaining structure. The slope itself, created from calcareous clay, would have been placed in successive 200 mm layers, compacted to 95% Proctor

density by pneumatic tyred roller, after construction of the lateral retaining wall.

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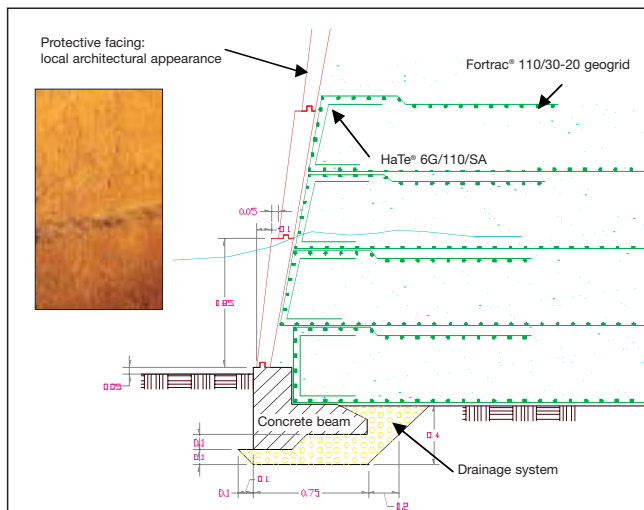
**Alternative using a geogrid**

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Due to the operating constraints on the McDonald's restaurant in Agadir and the seasonal nature of commercial activity in the town, the client was required to bring the restaurant into operation within an overall lead time of 4 months. However, 4 1/2 months were required just to construct the retaining walls and complete the structure, increasing the delay to 7 months before the restaurant could be opened, with the developer losing a full season's use.

The consultant proposed that a geogrid be used to create the lateral retaining wall, using an easily compactible clean sand as fill material. The client agreed to follow this solution, which revealed the following features:

- the use of **Fortrac**® geogrid, 110 kN/m tensile strength, with 500 mm layers using sand from the Agadir coastal dunes
- the sand used has a 38° friction angle with less than 3% fines  
it has been placed in a saturated state and compacted manually with vibrating plates, achieving a 97% degree Proctor density (16.05 kN/m<sup>2</sup>)
- the overall height of 5.50 m has required 6 m anchorage lengths of geogrid for the upper layers to accommodate the region's seismic problems and 3 m lengths on the lower layers  
the slope facing is set at 80° to the horizontal installation of this system has been facilitated by the use of a metal shuttering system and the following precautionary features:



- a reinforced concrete beam providing the following three functions:
  - acting as a guide for the contractor while installing the geogrid
  - acting as a toe retention to improve the slope stability
  - supporting the protective facing

- a protective facing comprising units of 0.80 x 0.80 x 0.05 m, covered with traditional cob (mud), ensuring protection of the geogrid against vandalism  
these protective elements have been designed to reflect the architecture of the ksours (villages) in South Morocco
- a drainage system, designed to collect all the seepage water and drain into a downstream cesspool, connecting to the town's drainage network and incorporating an external inspection chamber
- reinforced concrete corners, namely two 120 mm thick reinforced concrete sections, to ensure a good connection at the corners and retain the 80° slope



## Advantages

The total structure, including the **Fortrac**® 110/30-20 geogrid and all the protective work (excluding the facings) provided the following essential advantages:

- only 3 weeks' delay in execution
- savings of 27% over the initial solution using reinforced concrete

It is thanks to this solution that the restaurant was able to open in accordance with the developer's wishes and that the '99 season was not lost.

## Sea front improvements at the Hotel 'DUNES D'OR', Agadir.



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### Advantages

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Under the scope of privatisation, the international tourism operator, FRAM, acquired the DUNES D'OR hotel in Agadir situated on a bay immediately to the south of the town.

General improvements have been undertaken, including the construction of new premises (conference centre, etc.) to bring the hotel up to FRAM's standards. The sea front had to be laid out in terraces sloping down to the beach.

The beach itself presented two separate problems:

- being open to the public, it allowed free access to the hotel
- the bay at Agadir is subject to intense erosion resulting in significant loss of the shoreline (approx. 3 m per year) and quite heavy swell (particularly during the equinox periods)

The client therefore had to securely stabilise the sea front and provide a physical boundary for the hotel. The initial proposal

was to handle these problems by means of masonry walls using stone from the Anza quarry to the north of Agadir.

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### Project modification to suit the site

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The client had severe constraints regarding the opening of the hotel (the first customers would be arriving for Christmas '99). An engineer was initially consulted regarding a simple problem of reducing the delay.

Examination of the masonry wall project revealed various major technical problems:

- the walls were rigid and therefore strongly reflected the swell from the waves combined with the powerful equinox tides
- such rigidity was ill-suited to construction on a sandy beach
- furthermore, all the masonry walls on the beach exhibited damage within a year or two
- their construction would require considerable foundation work, not ideal for terracing at significant depths in fine sand



The engineer, in collaboration with the architect, consequently proposed the alternative option of a supporting structure using **Fortrac® 55/30-20** geogrid. This system provides the following advantages:

- perfect granular continuity between the embankment and the sand supporting it since both have the same properties, thereby eliminating any problems of undermining
- ideal resistance to the action of the sea since such embankments



absorb wave energy very effectively due to their high permeability

- high mechanical flexibility due to the system's ability to deform, absorbing any local subsidence

The improvements, designed by the landscape architect, included several terraces 1.5 m high. To keep the terraces separate from the beach, the last terrace adjacent to the beach, was set at a height of 2.5 m.

The face of the supporting structure is made up of 3 layers, each 0.5 m thick (5 layers 0.5 m thick in the case of the terrace fronting the sea).

The main body rests on an embedded layer of stabilised sand, confined in a woven geotextile fabric (nominal pore size 0.2 mm).

This aperture is compatible with the sand particle size.

The vertical geogrid face is lined with the same geotextile fabric described above to prevent sand migration.

The system was installed using formwork inclined at an angle of 80° to the horizontal.

The client and his landscape architect are planning to cover the facing with vegetation, which will also serve to protect the geogrid.

The building work was completed in one month, even before the other interior improvements were complete.

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