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Environmental policy for landfills and role of geosynthetics in Greece

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ABSTRACT: The safe and correct disposal of domestic and industrial waste, most crucial environmental problem in Greece, is faced by specific legislation laws according to the European Community directives, involving natural and geographic criteria (geography, morphology, geology, geotechnical feasibility, hydrogeology, social effects etc.). The mainly calcitic geological bedrock does not allow a wide selection of adequate places according to the environmental criteria, therefore geosynthetics help in this section has since 1990 provided the design engineers with a very important tool. Future expansion of geosynthetics use in landfills is imminent, therefore strict legislation criteria will soon be adopted on their properties (installation and performance criteria prevailing). Special quality control during construction and monitoring during the function stage assure the best performance of the selected site.

1 GENERAL - BACKGROUND INFORMATION

The solid waste disposal, mainly domestic waste, is in principle an urban problem. Some decades ago, the Greek countryside with its almost agricultural character did not face any waste disposal matter, since nearly all rests were useful and recycled. The staged development of a large amount of urban and suburban centers, in relation to the change of consumption habits and the tourism rapid growth created a rather sharp and crucial problem. The urban population in Greece produces actually an amount of 3×10^6 tn of domestic waste per year that occupy a volume of $17{,}5 \times 10^6$ m^3 and present an increase tendancy of approximately 2-5% annualy. The waste composition varies among the different urban areas depending upon the industrial and tourist development. Rather recent statistical analyses for the design of landfills indicated the following average percentages:

WASTE TYPE	PERCENTAGE (%)
Paper products	43,8
Food rests	18,2
Metal	9,1
Glass and ceramics	9,0
Garden waste	7,9
Man - made deposits	3,7
Plastic and leather products	3,1
Cotton products	2,7
Wooden products	2,5
TOTAL	100,0

The above composition gave an important push to recycling research and development of techniques, aiming at the minimisation of the annual waste volume. Nevertheless, the environmental problem of waste disposal continued to increase, and special legislation was developed in order to minimize the pollution effects of the landfills. In the beginning of 1970, the selection of a waste disposal location was based upon specific natural - geographic criteria, such as the site morphology, geological and hydrogeological conditions, climatic conditions, geotechnical limitations and social side effects. By the end of 1979, approximately 300 locations for waste disposal were already employed and an adequate map at a scale of 1:500.000 was issued. By this date, no strict legislation existed and only the 6% of them was actually conform with the specific norms, while 12% of them had presented minor environmental problems that could be remediated, if adequate measures were taken. Analytical record tables had been issued presenting for each location the specific basin run - off, the geological condition and subsoil permeability, the average slope of the location as well as its climatic conditions. Up to that day, no geosynthetics were employed in any of those landfills. In 1986, the European Community Directive 75/442/15-7-75 entered into the Greek Legislation and was the basis of development for all further laws and directives. The Ministry of the Interior in collaboration with the Central Union of Cities and Municipalities took over the responsibility for the installation of landfills by employing special design criteria and a more detailed quality control during construction.

2 ENVIRONMENTAL POLICY - LANDFILL DESIGN AND CONSTRUCTION

From the beginning 1990, the design of a landfill is considered as the task of specialised consulting companies and is based upon the main European directives, enriched by ministerial decisions and guidelines concerning the feasibility study, the preliminary and the final design, as well as the issue of the necessary tender documents. Each stage is submitted to approval before elaboration of the next one and during construction, the consulting companies having dealt with the design are often asked to assist and comment certain aspects of the projects.

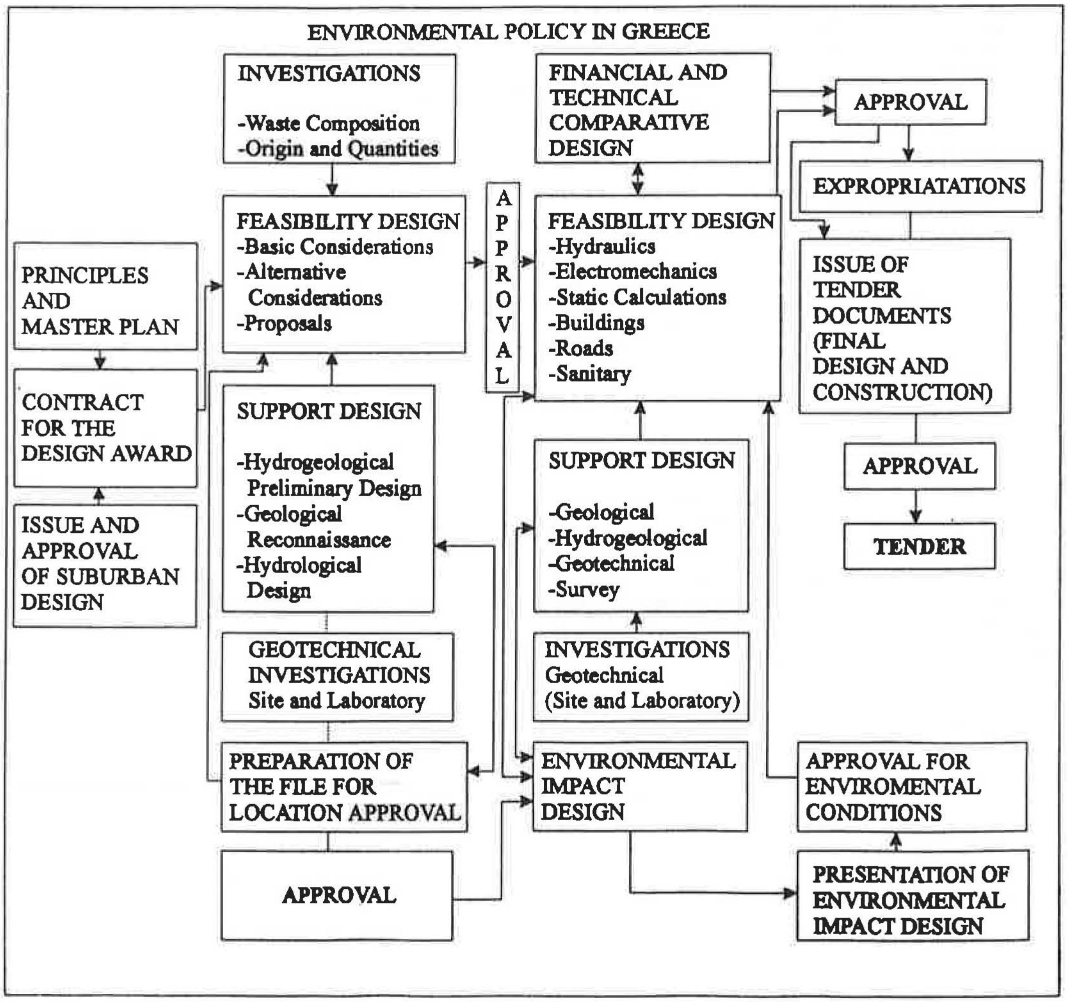
As presented in Figure 1 (flow chart indicating the actual legislation policy in Greece), a typical design procedure involves three intermediate stages:

The first stage includes investigations on waste data, feasibility design, support design on preliminary geological and hydrogeological matters and preliminary geotechnical investigations.

The second stage follows upon the location approval and includes detailed feasibility and support design in conjunction with financial and environmental impact design.

The third stage follows upon the final approval and includes the issue of the tender documents while at the same time the procedure for expropriatations is active.

The site selection criteria applied mainly during the feasibility stage and preliminary design are rather strict and generally include the following items:



• Morphologically mostly adapted locations are considered rather flat areas with 0 - 5 % slope, natural or man - made sinkings such as canyons and quarries, not affecting the hydrographic network of the area.

• Geographically, those locations should be situated among urban areas at equal distances and away of inhabited zones, archeological places and airports.

• Climatic conditions influencing the site selection are the wind, the sun - shiny, the temperature, the humidity, the rain - impact, the days of snow and freeze and the evaporation.

• Geological and hydrogeological criteria consisting of the geological and tectonic structure of the site, the lithological composition, the stratigraphy, the joints and faults density, the weathering grade and the erosion conditions of the soil strata.

• Geotechnical criteria concerning the stability of foundation and slopes, the suitability of materials referring to the daily covers and the final cover of the site and general foundation conditions of the necessary service buildings and access roads.

According to the existing legislation, special attention is given to the quality of the cover soil material, classified as daily, intermediate and final. Daily cover has a thickness of 0,15 m, intermediate covers have a thickness of 0,30 m and final covers thickness vary between 0,60 m and 2,00 m. Special directives for the final cover (layering, compaction etc.) are also provided, so that minimal secondary long term settlements are assured. The top plantation and final land use are subjected to special recommendations, task of the designer of the landfill, too.

3 THE ROLE OF GEOSYNTHETICS

The necessity of minimisation of the pollution and contamination risk that is always very crucial in the waste disposal landfills (toxic gasses from organic materials, superficial pollution due to water flow, deep water contamination due to leaks of the landfill) is especially mentioned in the existing Greek legislation. In addition to that, it is very important to state the calcitic nature of the existing geological bedrock, a fact that leads to generally high permeability of the limestone formations encountered at approximately 70% of the territory (karstic voids, faults, discontinuities and tectonic zones are very common and numerous almost everywhere). To remediate to that, the existing directives state that water - proofing of each landfill has to be assurred by "a best, most cost - effective combination of impermeable plastic membranes and suitable soil layers".

Based upon the existing geological studies performed in Greece, the geological formations indicated as most appropriate for landfills installations refer to clayey and metamorphic ones. These formations include mainly neogene marls and clayey sediments, flysch formations, schiststones and gneiss, presenting low to negligible permeability and therefore demanding cheap interventions to assure water - proofing effects. The existing acquifers must be situated at least 10 m below to the landfill bottom, otherwise special measures are to be taken into account.

In all other cases, an addition of adequate geosynthetics is necessary to improve the bottom impermeability and meet the imposed environmental restrictions.

The minimum requirements for the specifications of those geomembranes are still practically inexistant (the term "impermeable" is only prevailing) and the designer should, at each stage of the design, determine the type, thickness, application method, monitoring method and cost - effectiveness of his proposal. As a matter of fact, landfill geosynthetics design in combination with borrow clay layers of adequate thickness has been, since 1990, based on international techniques and practices imported in Greece by specialised companies. There is actually a certain number of private companies that collaborate with the local municipalities in two various forms: Either offering a complex of "design and construction method with some years of exploitation" or offering simply a specialised design, up to the issue of the tender documents. The association of geomembranes to protecting geotextiles and geonets is now rather common and most designers apply design rules copied by international experience . In this way, a system of minimum requirements for the geosynthetics proposed for application has been unofficially established (in spite of the lack of classical geosynthetics specifications in this section) and materials approval during each design stage is performed by a special technical committee organised by the project Owner. Very often, geosynthetics specifications from other sectors are borrowed (e.g. water - proofing geomembranes in tunnel construction, protecting geotextiles in underground garages), and the design engineers are mostly assisted by chemical engineers and environmental specialists concerning the interaction between the type of waste and liquids and the type of geosynthetics involved. It is rather encouraging to notice that no serious failures have up to now been observed, but the relatively short periods of application (7 years) do not allow for final estimations.

As no official specifications for the type of geosynthetics and their association to clay barriers actually exist, it is rather difficult to state which water - proofing method is in each case of landfill design applied. As a general trend, HDPE geomembranes are mostly applied, having a minimum thickness of 1,5 mm, associated to either schist bedrock or clay barriers of 0,30 - 0,50 m thickness. Special draining zones of aggregates (0,50 m) separated by non - wooven, thick geotextiles (5 mm) are always present in the design of the bottom of the landfills. In no case double water - proofing layer (two geomembranes associated with two clay barriers) has ever been used, since the cost of this solution was extremely high. The final cover is also rarely associated with a geomembrane, but always includes a clay barrier of important thickness and is designed with special slopes, allowing for quick evacuation of surface waters.

Conclusively, the need of minimum requirements for the geosynthetics used in the sector of landfill design in Greece is now primordial, having spent 7 years of design and construction experience. These requirements may be issued by comparing the existing international relative documents with the experience already acquired in Greece and will be valuable for obtaining the best evaluation of design methods and application techniques in conjunction with lower total costs for each project. Further steps on the remediation of certain already constructed landfills, that have not been adequately water - proofed, are now considered as a second, but also very important, priority, which as well depends greatly on the need for minimum requirements.

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