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Taking Flood Risk Into Account In High-Speed Rail Way Line between Tangier and Kenitra

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***Abstract—* The high-speed railway line between Tangier and Kenitra was conceived in a particularly significant and constraining hydraulic context. To achieve specific demanding goals of hydraulic safety and "transparency", the studies called for different hydrological and hydraulic methods adapted to the context of the project and developed by a group of expert specifically requested for this project and sophisticated tools such as calculation models for watershed flows.**
***Keywords—*Flood risk, high-speed railway, watershed, hydrology, flow.**

I. INTRODUCTION

The project of High-speed railway line (HSR) Tangier-Kenitra with approximately 200 kilometers length is the first stage of the project of "Atlantic" HSR connecting Tangier-Casablanca-Marrakech. The travel time between Casablanca and Tangier will be reduced from 5 hours and 45 minutes to 2 hours and 10 minutes [1].

TABLE I
DIAGRAM OF LOCALIZATION OF THE HSR

The line of the high speed train starts from the city of Tangier; it crosses then the highway from the exit of the city to cross then the reliefs of Marhar. The HSR crosses the relay station of Breich to pass near the town of Assilah by the East before intersecting the highway from the east.

The project crosses then the forest of the Sahel then the large plain of the Loukkous Wadi before intersecting the highway from the east again. The line continue to follow the highway east between Douar Lakhnacha and wadi Al Fakroun.

The HSR crosses then the large plain of Gharb in which runs out the Sebou wadi. The final portion of the HSR Kenitra - Tangier constitutes the bigining of the future prolongation of the line towards Casablanca which will be the second phase of project HSR Tangier-Casablanca.

The line crosses about ten secondary rivers and two principal rivers: the Loukkos Wadi and the Sebou Wadi. It also crosses the marshes of Loukkos and the forest of the Khemis Sahel which are classified as SIBEs (Sites of Interest Biologic and Ecologic). The line avoids Merja Zerga and passes at the South-eastern end of the Tahadart complex also classified as of SIBEs [2].

II. VULNERABILITY OF THE RAILWAYS

In the presence of the floods, the railways present vulnerability stronger than roads. The road infrastructures for their great majority and on condition of moderate rates of flow or particular installations such as "concrete pavement", can take the consequences of floods without important effect on the safety of people or traffic. In case of flooding of a railway platform, it is the stability of the way itself which is compromised. In case of overflow of the flows on the embankment, this last without coating risks very strongly to fade by driving the ballast, then materials of the embankment itself. The damage is substantial and implies either a regeneration of the structures of bases of the way or a complete rebuilding of the railway. Moreover, the high speed character of the infrastructure returns circulations and thus safety of people even more vulnerable on either train speed or frequency [3].

III. THE LEGAL AND INSTITUTIONAL FRAMEWORK

With an effervescent economic activity, an intense urbanization, and fragile natural circles and in front of environmental problems which touch particularly the quality of water, the environment does not stop taking an unequalled scale and showing itself on various territorial ladders. Faced with this situation, institutional and legislative reform recasting has been introduced since a few years in an objective of protection of water resources and their integrated and decentralized planning and also sustainable development. The national environmental preservation policy currently being implemented in a legal and normative framework fits on one hand into the process of installation of respectful development projects of the international conventions ratified by Morocco, and on the other hand into the implementation of procedures established by the sponsors and within the framework of Morocco's general upgrade out of globalization and open borders. The environmental studies allow to estimate the direct or indirect effects on the environment in short, medium-term and long term of the various projects, activities, installations or agricultural or commercial industrial and to propose measures to eliminate, attenuate or compensate for the negative impacts [4].

IV. PHYSICAL CHARACTERISTICS OF THE SITE

The physical characteristics of the site are as follows [5], [6].

A. Climate

The climate of the area of study can be divided into three units:

1) *Tangier-Assilah:* Mediterranean climate with oceanic influence from Tangier to Assilah: the temperatures remain lenient in winter, soft in summer as well on the coasts as at high altitude. They rarely reach 0°C in January and the most frequent maxima of this month fluctuate between 14°C and 18°C. In summer, the atmosphere warms significantly; the maximum temperatures most frequent in July vary between 16°C and 26°C. Inter-annual average pluviometry is of 900 mm.
2) *Sahel-Moulay Bousselham:* climate thermo Mediterranean wet in winter with a very marked oceanic influence and a relatively low thermal amplitude. The monthly average temperatures are from 10,5°C to 12,5°C in January and from 22,5° C to 26,0°C in August. The annual averages precipitations are about 700 mm. They are concentrated on November to February with irregular falls in October and March and April. The climate from May to September is generally dry.
3) *Gharb (Moulay Bousselham - Kénitra):* Mediterranean climate; Soft and wet in winter; hot and dry in summer, precipitations in the area exceed widely the national average. The area of Gharb receives abundant precipitations, everywhere they exceed 600 mm. Two rainy periods can be distinguished during the agricultural year:
   a) From October to April: the most rainy period (785 mm), whether 76% of annual precipitations;
   b) From May to September: the least rainy period with 24% of the total of annual precipitations. The average temperature varies between 14°C and 23° C.

B. Superficial waters

The main rivers crossed by the HSR are:

1) *Mghogha wadi:* The Mghogha wadi is the largest wadi which crosses the city of Tangier. It culminates at 415 m of altitude with a 17 km of length and a catchment area of 74 km², with an average gradient of 1,2%. The banks of the wadi are extremely degraded and its bed is blocked with waste. In its current state, the wadi is more similar to a collector of waste than a real river. In the upstream part of its course (upstream of the km No 4,4) this wadi is channeled.
2) *Wadis Mharhar, Hachef and Gharifa:* El Hachef is retained by the dam of April 9th 1947, and Mharhar is retained by the dam

Ibn Battota. The two wadis meet near the marine coast inside the site Ramsar Tahadart The Gharifa wadi is located in the south of Tahadart and it has of lower surface and flow. It is a small wetland annexed to the site Ramsar Tahadart and largely made by a salted steppe.

3) *Loukkos wadi:* The Loukkos wadi presents a pluvial hydraulic system with an inter-annual irregularity. This river is setteld through the dam El Makhazine with a capacity of 773.106 m3, which offers a possibility to irrigate approximately 85.000 ha. A dam with a capacity of 4.10m3 was installed downstream on the Loukkos wadi, with less than 1 km in the east of project HSR, in order to protect its low valley against upwelling of sea, and to ensure a sufficient source of water for irrigation.
4) *Drader wadi:* At KP 116+750, the high-speed railway line crosses the Drader Wadi. The crossing of this hydraulic constraint is ensured by a structure of an opening of 25m. The importance of this river is due primarily to its variously in Merja Zerga, a watery ecosystem of great faunistic and floristic richness classified site RAMSAR. Located at the upstream of Merja Zerga, it presented important influencing of fresh water before this role is not tiny room following the exploitation of its water by agriculture. In an initial state, the flow noted for this river to the upstream of the point of crossing of the HSR according to the recordings available, is from approximately 80 m3/s.
5) *Nador channel:* On the level of the km No approximately 130, the HSR crosses the channel of Nador. The crossing of this hydraulic constraint is ensured by a work of art of gauge and geometrical and dimensional characteristics adapted to the hydrological, geological characteristics and geotechnics of the receiving medium.
6) *Sebou wadi:* On the level of the KP 182, the line of the HSR crosses Oued Sebou. The crossing of this hydraulic constraint is ensured by a viaduct of 230m of length. Taking source with the Average Atlas and pouring in the Atlantic on the level of Mehdia close to Kenitra, Sebou extends over a 614 km of length. It crosses the pre-Riffian zones and the plain of Gharb and receives the affluent of several wadis of these zones, like wadi Lebène and Ouargha wadi on the level of the pre-Riffian zone and Beht wadi and wadi R' dom on the level of the plain of Gharb. The flows of the wadi vary according to the seasons of the year. On the level of the zone swallows, which will receive the project, this flow is on average of approximately 140 m^3/s which can reach median values in winter of 350 m^3/s and a value of peak of 2700 m^3/s (which is besides the value recorded for the year 2010 and that taken for the dimensioning of the viaduct on Sebou). Considering its site in a zone full with human activities, Sebou is the Moroccan wadi which receives most of the rejections and of polluting loads forwarded to rivers. It receives all the wastes domestic and industrial of the town of Fès, the rejections of the agricultural activities and agroalimentary along its course (the sugar refineries, oil mills…) as well as the industrial and domestic wastes of the town of Kenitra. In bottom of the basin, activities of great fishing are carried on by the local population realizing of small artisanal boats. However, the importance of the watery faunistic life of this wadi remains a priori limited because of pollution of the river

C. Subterranean water

On the high part of the basin loukkos, reign of the impermeable and very permeable facies which do not allow the constitution of important aquiferous formations. However, in low Loukkos and the coastal strip one finds very important aquifers, the subterranean water is contained there in a whole of aquifers with free tablecloths primarily made up of sandy and sandy formations.

V. METHODOLOGY AND DISTRIBUTION OF STUDIES

Taking into account all of the characteristics and context in which the project of the HSR Tangier-Kenitra fits, the methodology of study as well as the computational tools have being adapted to the objectives much more demanding than those usually required. The crossing of the obstacles was the subject of specific studies with mathematical modeling by specialized research departments.

In this context, the following areas were investigated [7]:

A. The reliefs of Mharhar (From the KP17+000 to the KP19+000),
B. The zone of the station of relay of Brich (From the KP31+000 to the KP37+000),
C. The zone of Assilah (From the KP37+000 with 48+000),
D. The relief of the zone of forest of the Sahel (From the KP58+900 to the KP69+000),
E. The compressible grounds and the floodplain of the wadi Loukkous (From the KP80+400 to the KP82+800),
F. The compressible grounds of the Sebou wadi and its fields of flood (From the KP169+920 to the KP184+800)
G. The residential areas on the side of Kenitra (zone of allotment towards the KP187+400)
H. The plan of installation in the South of Kenitra

The loan of the floodplains of the Sebou wadi and the Loukkous wadi was entirely modelled mathematically in permanent and transitory mode [8]. These modelings which extend on several tens of kilometers made it possible on the one hand to delimit the decennial and centennial floodplains, and on the other hand to make sure of the borrowed absence of office plurality of the incidences of the project all along of the way.

Concerning the crossing of the basins slopes, an group of expert examined the methods of estimate of the flows and dimensioning of the hydraulic works of the basins slopes in order to bring the adaptations necessary to the pluviometric characteristics of the zone of study [9].

These studies recommended the reinforcement of the insufficient existing hydraulic works by the addition of certain a number of hydraulic installations such as channels, tubes, ditches out of concrete, ground ditches, intercepting ditches, protections by gabions and ripraps, of the etc, surrounding walls… [10]

VI. CONCLUSION

The examples presented here show the richness and the importance of the results that have been obtained thanks to the use of varied tools and complementary methodologies. The observation of phenomena when we have the opportunity to see them realized incites with to greatest caution as for the precision of calculations and the measures carried out on these modeling which remain very theoretical. Each event is unique in its hydrograph, its flow, its duration… Also, the inclusion of safety margins on the watermarks and the rates of flow for the hydraulic dimensioning of the structure is the only way to ensure the sustainability of the work [11]. Paradoxically, one can consider that the estimation of the incidence of a project based on a relative calculation between an initial state of reference and a projected state remains reliable and with a good level of precision [12], about what is measurable in the natural conditions (+/-5 cm in height of water, + - 0,1 m/s average speed, +-1% of the volume of the flood). The impact of the project on coastal population’s safety can be quantified with sufficient reliability, which leads us to consider the tests of vulnerability as an essential and inescapable stage in the conception of the infrastructure [13].

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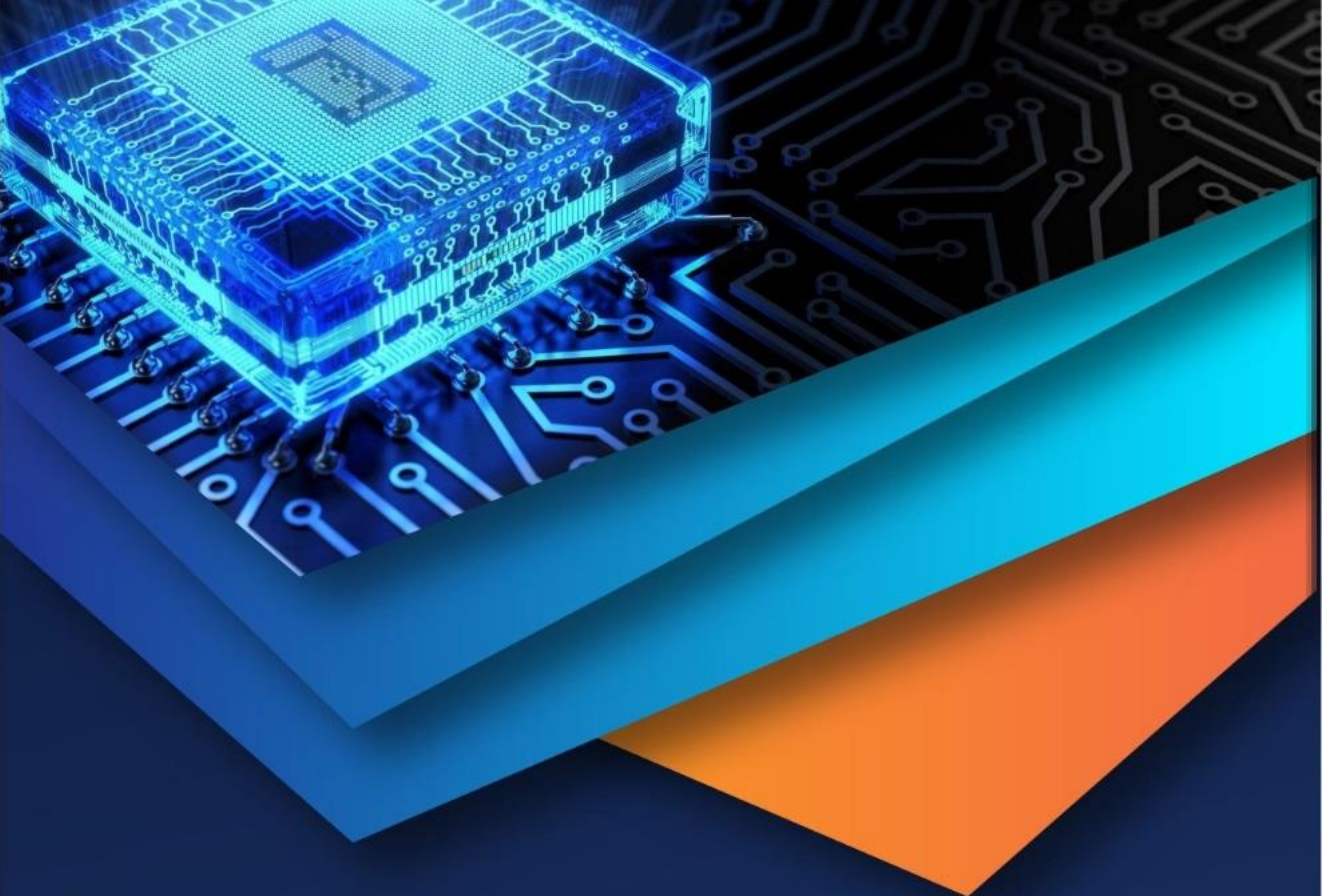

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