Simulation and determine hydraulic capacity Gorsouzan estuary in urban flood whit use HEC-RAS model (Case study: Part of Bandar Abbas)

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Expanded Abstract

Introduction

The flood can be considered as the most important natural disaster which has the highest probability to occur, and has the most impact on the people life in comparison with the other natural risks. Furthermore, climate changes increase the probability and frequency of flood. The floods have direct relationship with the social and civil problems, environmental problems, and economic losses. Evaluating and managing the flood risk is a base for identifying the current risks, the ready areas for flood and reducing the future flood disasters. The Hydraulic Simulation Models are a proper substitute for improving and managing the channel function by understanding the flow behavior in channel network. HEC-RAS software is provided by Hydraulic Engineering Center which is related to the engineering team of America army, to analysis the river system. by the fifth version of HEC-RAS model. The user is able to one dimensional and two dimensional simulation of the unstable flow. The HEC-RAS model is an integrated program which calculates the water surface profile by using the energy equation.

Materials & Methods

The coastal city of Bandar-abbas is the capital of Hormzgan province and is located in the south of Iran. This city, in the north of Hormoz strait, is on the way of some runoffs which are coming from Geno Mountain and going to the sea. This transport is done by the five estuaries. These estuaries are acting as the drains of the city which disembark the surface runoffs of the city to these estuaries. The under study area includes Gor-souzan estuary in the coordinate of northern 27 degree and 10 minute and 30 second to 27 degree and 12 minute and 30 second, eastern 56 degree and 15 minute and 30 second to 56 degree and 18 minute and 30 second which is a part of city with the area of 0.252 km^2. The height change of the district is between 1.05 and 44.58.

Gor-souzan estuary channel was drawn in the Arc GIS, 10.2 versions, based on the map DEM with 2*2 mm^2 pixel, and 1.500 tilt and blocks. In the section of the geometric data of the HEC-RAS model, to determine the exact border of the channel bottom and its surrounding and also to control the high points of the channel bottom by a GPS device, the number of the Ground Control Points in each 500 m range was considered 32 points. All of the points were moved to the Arc GIS environment. Then for rivers geometric simulation, after providing the Triangle Irregular Network model (TIN) by the use of the existing tools in the appendix HEC-GeoRAS, the layer of the estuary's main channel, 6 subsidiary channel, 170 cross- section on the estuary's main channel and 3 cross- section on each estuary's subsidiary channel and the effective parameter of the Blocked obstructions were drawn.

The format of the mentioned parameters are changed and moved to the HEC-RAS software. Some of the parameters including six bridge structures and two culverts, contraction coefficient caused by sections narrowing equal to 0.1 and the expansion coefficient caused by sections opening equal to 0.3 were considered. One of the important and effective parameters is Manning roughness coefficient. This coefficient was determined based on frequently field visits in the different channels sections, model guide, experts ideas, the offered tables in the technical books such as the Hydraulic of the Open Channels and Chow method, for the main section of the channel between 0.016 to 0.024, subsidiary channels between 0.013 to 0.019, the sides of the main channel between 0.014 to 0.016, the sides of the subsidiary channels between 0.011 to 0.015, and right and left flood

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plain between 0.01 to 0.03. In the under study urban basin and upstream basin, there is no hydrometric station any discharge registration base. Therefore, we started to measure the flow speed and depth during five raining, in three points of the channel, by the help of gauge and current meter. The Manning coefficient was checked in the sections that the depth and the speed of the flow were measured between 0.016 and 0.024, and the results were evaluated based on N.S coefficient and squares error and mean.

In the other hand, there are two natural basins in the upstream urban district. There is no rain measuring station with discharge in these two basins. In order to determine discharge or return period, the nearest station, called Bandar-Abbas rain measuring station with 30 year statistical period length, from 1392 to 1362 was used. And by the method of soil conservation structure (SCS), different discharge or return periods were calculated. In order to do calibration of soil conservation structure (SCS) model in the output and begging of the urban upstream basin, the input discharge of the upstream was measured during a rain occurrence.

In order to determine the capacity of the hydraulic channel, after modeling the under study range with the different discharges, rating curve of each section was formed. Then the height of the Bank Station Points (or the border points in which the flow point overflows from the section) in the right and left sections were determined. In the place of separation of the main section of the channel from the right and left flood plain (in the place of Bank Station), the number of right and left points of the river were studied and moved to the discharges, rating curve. From discharges, rating curve, the flow discharge corresponding to the right and left points of the channel were determined and the least flow discharge (from two studied discharge) was considered as the secure discharge or capacity. Then, finally, by the help of the existing information of the interval geometry and the flow kind of the performed model, the flood areas of the return period were calculated. Flood level in the different sections, among all output data of HEC RAS model including the water depth, flow speed in the different sections as the output were considered.

So, the output data was entered GIS environment in order to provide the flood area. In the Arc Map, by using HEC-RAS outputs, the maps like the flood area per each return period was obtained. To determine the absolute sensitivity of each parameter, we calculated the relative sensitivity level (SL) according to it the flow features are categorized based on their level of importance. To analysis the model function in calibration phase of the statistical tests, two methods of the error analyses are considered. The first one is Nash-Sutcliffe efficiency, and the second one is Root Mean Square Error. In this part, in order to study the flood with the different return period in Gor-souzan estuary and the flood area of each of them, we have simulated the hydraulic behavior of the flood flow in the stable mood. And this simulating is proposed in four scenarios.

In first scenario, we have no input discharge from the upstream basin, and the sea is tide. The upstream and downstream border condition is introduced as the normal depth.

In second scenario, we have input discharge to the urban basin from the upstream out of the city basin, and the downstream condition of the urban basin which ends to the see and is considered as the sea tide condition. To define the downstream border condition, the six normal depth methods were used.

In third scenario, we don't have the upstream discharge input, but the downstream condition which is the sea and is the high. In this condition in order to define the downstream border condition we measured the water height in the estuary. This measurement was done in the time of maximum high. Therefore, in order to introduce the height of the high, we used the known W.S option for the downstream condition. And the upstream condition was introduced as normal.

In forth scenario, we have the upstream basin of the input discharge to the urban area. In the downstream condition, the sea is high. In this scenario, for the upstream condition, input discharge of the out city basin, and for the downstream condition, the height of the high water, was introduced.

Results

By considering that the flood with the return period of 25 years was chosen as the flood of the study designs and the base of the determining the basin limit and the under study district, so with the increase and decrease changes of the manning coefficient, the sensitivity of the average changes of the water height and the flow speed mean of the Gor-souzan estuary were evaluated. The results showed that by increasing the Roughness coefficient, the amount of the water depth increased, but the flow speed showed an inverse relationship. The results of the evaluation showed that by considering the RMSE and N.S factors for the water depth and the flow speed, the simulation model of HEC-RAS has proper efficiency. The results of the calibration of the Soil Conservative Structure (SCS) is also caused by the proper efficiency of the model. The result conclusions of hydraulic simulation of the under study estuary flow is presented in the following based on the different scenarios.

Scenario 1: Based on the first scenario, not entering the flow discharge from the upstream and the tide condition of the sea, the capacity of all intervals of the main channel of Gor-souzan estuary has the ability to transport the flows with the different return periods. Of course, in some intervals, some parts of the estuary channels do not

have the ability to carry 100 year discharge. But, the most of the intervals own the ability to carry discharge with the different return periods.
Scenario 2: In this condition on average, from the first interval to the fifth one, has the ability to carry 10 to 25 year discharge, and in some parts there is the ability to carry discharge with 50 year return period. But in the sixth and the seventh interval, the best ability of these two parts of the channel is in transporting the discharges with under 100 year return period.
Scenario 3: In this condition, the situation of the first to the fifth intervals of the channels is the same of that of the first scenario, but in the sixth and the seventh intervals, because of the high water condition and rising the sea water in the estuary, the ability of discharge transportation from these parts in the different return periods decreases to 23.5 and 40, respectively.
Scenario 4: Based on the fourth scenario, the first to the fifth intervals show the ability to carry discharges with 25 year return period. The sixth and the seventh intervals, with the high water condition in some sections, and full capacity, generally have shown a good ability to carry discharge with 50 year of return period.

Discussion and Conclusion

In this research for zoning the flood risk, we have used the combination of two hydraulic and hydrologic models, because of the lack of any data related to the flood and not existing any hydrometer station. At the first the Soil Conservative Structure (SCS) method was used for the hydrologic calculating. By considering the measurements of the depth and flow speed in three sections of the channel, the results of the validation showed that this method, by considering data shortage, can present good results, as in the calibration level, on average, the statistical coefficient amount was higher than 0.75, which shows the good simulation. In the following, to study the hydraulic behavior of Gor-souzan estuary, we used HEC-RAS model. Also, to calibrate the roughness coefficient as an effective factor in the simulation procedure, the measured rain was used. The obtained results from calibration and validation of HEC-RAS model, between the amounts of model simulation and the observations of the water depth and flow showed that based on the statistical coefficients RMSE and N.S. This model has a proper efficiency. Therefore, in each measured sections, the average amount of the roughness coefficient was determined. These results are correspondent to the findings other researchers in the field. Also, the findings show that HEC-RAS model with the high accuracy and low cost can be used for studying the hydraulic features of estuary channel flow, by considering the conditions of Bandar-abbas city which is located on the coast.
From the other hand, the two software Arc GIS and HEC-RAS have the proper ability to show the results of the flood zoon, and this is correspondent to Patel and Gundaliya, 2016. The results of the flood zoning shows that from the total of the area in the 100 year floods zoning, on average about 50.5% are ready for flood by the floods with the return period of 25 year or less. This is correspondent to the findings other researchers, who know the percentage of the 100 year floods zone ready for the 25 year floods. Existence of the tide and high water, which has impact on the Gor-souzan estuary channel, is somewhat uncontrollable.
Based on the third scenario and the condition of the high water, although some parts are faced rising the water, but still the estuary channel has the ability to transport the 100 year discharges. But, based on the second and the forth scenarios which we have input from the upstream basin of the discharge, the capacity of the channel is decreased extremely and we observe the extreme floods, it is shown is 7 to 10 figures properly. In fact the estuary channel only has the capacity to transport the discharge of the urban area. Therefore, by considering the urban planning, we must pay enough attention to this problem.

Keywords: flood, Gor-souzan estuary, hydraulic capacity, sensitivity analysis, zoning.