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SELECTION OF DAM AXIS USING AUTOCAD CIVIL 3D A CASE STUDY OF JACHI DAM, MANI LOCAL GOVERNMENT AREA, KASTINA STATE.

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ABSTRACT

Selection of right dam axis during preliminary design stage is needed to provide right locations to save time for alternative comparison in design proposals. This study was carried out to select the best dam axis of Jachi propose dam site using AutoCAD Civil 3D with data of topographical survey of the area. Three alternative dam axis C, C2 and C1 were located and their Embankment volume, reservoir capacity and storage ratio obtained as 107.972.71m^3, 240,233.08m^3, 240,232.06m^3 and 2,350.854.84m^3, 3,350,554.54m^3, 1,103,797.83m^3 and 16.52, 13.73, 4.59 respectfully using AutoCAD Civil 3D, with alternative C having storage ratio of 16.52 indicating excellent rating site for dam axis design. The obtained results indicate that careful selection of dam axis using AutoCAD Civil 3D can save time with more economical design proposal.

Keywords: *AutoCAD Civil 3D, Topographical Map, Storage Ratio, Dam Axis, Dam Embankment.*

INTRODUCTION

Dams provide a cost effective way of storing water for irrigation, water supply flood control, hydropower generation etc. successful dams require planning, proper site assessment, design, construction and maintenance. A satisfactory site for a dam reservoir must fulfill certain functional and technical requirements to balance between the natural physical characteristics of the dam site and the requirement to meet cost effective and stable dam reservoir design and construction for economy.

Preliminary study

In the preliminary study phase, which may extern over a substantial period of time, the principal objective is to collect adequate topographical, geological, hydrological survey data, large – scale maps and any records

already available to provide the starting point, preliminary survey provide a base to analyze data for reconnaissance site investigation to identify site location for feasibility study.

Reconnaissance Survey

The purpose of a site reconnaissance visit is to gain an understanding of site characteristics. Potential problems as well as solution and for input to site selection of the main project stations such as temporary facilities head – works power house, preliminary access road and transmission line routes.

Dam Axis Site Selection for a Reservoir

The first step-in constructing a dam is to identify the best location. The selection of a suitable site for dam construction is very important and this should be finalized after preliminary investigations of few possible sites in the area.

In order to be cost effective, the dam should be located at an axis where maximum storage volume is obtained through minimum volume of earth fill, in selecting a proper dam site, due regard should be given to the technical expression "small mouth, big belly".

Feasibility Study

The feasibility report prepared at the conclusion of the preliminary study phase assembles and interprets all available information, data and records and makes initial recommendations with respect to the technical and economic viability of the dam axis option with regard to the location height reservoir capacity and material volume in terms of estimated cost and construction times. On the strength of this report a decision can be made with respect to further detailed investigations required to confirm the suitability of other dam requirements.

Scope

This study mainly attempted to locate Dam axis alternative for cost effective design proposal of dams and reservoirs during preliminary, reconnaissance and feasibility design report stage in planning development water resources project.

Study Area

Jachi Village

Jachi is located near Bakina village (about 6km NE of Mani, MANI L.G.A Kastina State), it has a catchments area of 163.5km2. [Ref Wakuti's Master

plan Area 'A' for northern part of Katsina Emirate]. From available records the mean annual run-off coefficient is estimated to be 0.12. Maximum river length from watershed to the proposed dam site is about 16.05km while the computed slope of the watershed is approximately 0.36%. There are no existing records of river flows at this station.

AutoCAD Civil 3D 2019.

AutoCAD Civil 3D is a software with dynamic modeling capabilities to create automatically adjusting 3D surface, alignments, profiles and corridors for terrain, roads and Dams etc. It is capable of interacting with sub-assemblies designed specifically for road and dam rehabilitation and reconstruction design. It is capable of interacting with existing conditions, analyzing them, and responding in ways that suit the design. (Autodesk, 2009).

Differential Global positioning system (DGPS)

The global positioning system (GPS) jointly developed by the Department of Defense, the department of transportation and the national Aeronautics and space Administration was fully functional by 1995. The system has three major components: space earth control, and end user. The space component consists of a constellation of 24 satellites arranged in such a way that they circumnavigate the earth in six orbital planes each with four satellites at any given time. Therefore, on average, a typical receiver on earth can track 7 to 12 satellites at any given time of the day. Each satellite continuously transmits encrypted information via carrier signal over L1 and L2 bands at 1,575.42 and 1,227.6mh2, respectively to GPS receiver so users can precisely identify their location on earth by the triangulation principal. (francios koening, 2007). The top crest width of 6m were generated using Assembly command of AutoCAD Civil 3D for the propose alternative dam axis.

Dam Embankments

The Embankment for the propose dam alternatives were generated using AutoCAD civil 3D Assembly, Day light bench and corridor command for the 3 alternative axis.

Key trench

The key trench or cut off trench for the propose alternative were generated using AutoCAD civil 3D Assembly, Day light cut rock and corridor commands.

Cross Sections

The Cross section at 20m interval for more precision for the 3 proposal were generated using AutoCAD civil 3D sample lines and section view command.

Dam Embankment volume

The Volume of earth work required for each dam alternative location were generated using AutoCAD civil 3D analyze command.

Data and Methodology

Data

The following data instruments were used for the study

- ✓ Survey Data
- ✓ AutoCAD Civil 3D
- ✓ Differential GPS
- ✓ Computer.

Methodology

Topographical

The site for propose dam design and construction were located a survey team consist of 2 surveyor and 3 chain bays were deployed to site and carried out contour survey of the propose dam site and reservoir using differential global positive system (DGPS) instrument to obtain a data to compute the topographical contour map of the propose area.

Plotting Contour Map

To plot the topographical contour map using the survey data, AutoCAD civil 3D software, Installed inside a computer was used to plot the contour map with contour interval of 0.5m, of the propose dam area.

Locating Alternative Dam Axis

After obtaining data from preliminary investigation, during the recognizance survey 3 locations were identified to certify the following factors.

i. The location should be characterized by a smallest of with.
ii. The valley must be distinguished the presence of high sloping sides
iii. The sides of the valley must be characterized by high elevations in order to be sufficient to accommodate the height of the dam.

iv. The area behind the proposed dams must have a high capacity to accommodate the amount of water collected.
v. The location should be characterized by a smallest dam axis length
vi. The volume of Dam for the propose location should be small with high reservoir capacity.

Plotting Alternative Dam Axis.

After the locations preferred for the dam axis has been identified, the coordinates were obtained using hand held GPS.

The data for easting Northing and elevation obtained using GPS were inputted into topographical map using AutoCAD 3D and alignments for 3 dam axis were generated.

Longitudinal Profile.

The longitudinal profile view for 3 alternative dam axis were created using AutoCAD civil 3D profile creation tools and profile view command with plotting propose Dam crest and excavation formation line on the profile views.

Crest Width

The minimum width of the propose dams crest is given by

Where H = Height of dam $W = \frac{H}{5} + 3 - (1)$

(us Bureau of Reclamation 1987)

The therefore from the longitudinal profile view of the 3 alternatives the dam height = 12m.

Substituting into equation (1)

$= W = \frac{12}{5} + 3 = 5.4m$

Say 6m.

Therefore, the proposed Dam crest width = 6m earth work volume was generated in volume table result of AutoCAD civil 3D.

Dam Reservoir Capacity.

The reservoir capacity of each propose dam alternative were generated at elevation 498 masl, a proposed spillway crest elevation for all the 3 alternative with 2m free board. The volume result was calculated by AutoCAD civil 3D using End area average method.

Storage Ratio.

The storage ratio is defined as the ratio of the amount of water retained to the amount of soil used to retain it. It's a good way to compare sites in a cost per benefit analysis. It can be a rough estimate and should not take the place of a detailed estimation once a site has been selected. Table 3.1 below gives an insight to comparison of storage rations. (Arora, 2003).

Table 3.1 STORAGE RATIO. Arora,2003.

Volume of storage/volume of Earthwork	Site Rating.
< 2.	Poor.
2-4	Good.
4-6	Very Good.
6.	Excellent.

.

Table 3.2. Propose Dam parameters use for the alternative site

Elevation of spillway crest.	498mash
Embankment upstream slope	1:3
Embankment downstream slope	1:2.5
Key trench bottom width.	4m
Bern widths.	5m.
Berm slope	0.00

RESULTS AND DISCUSSION.

Contour map.

The topographical map for dam and reservoir of the study area was plotted using AutoCAD civil 3D at a scale of 1: 10,000.

Dam layouts.

The layouts of the proposed Dam axis alternative C is shown in fig 4.3 below.

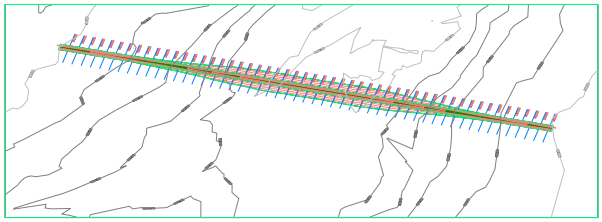

Fig 4.1 Alternative Dam Axis C Layout.

4.1 Longitudinal and cross sectional profiles the longitudinal and cross section view for dam axis C alternative is shown in fig 4.2 4.3

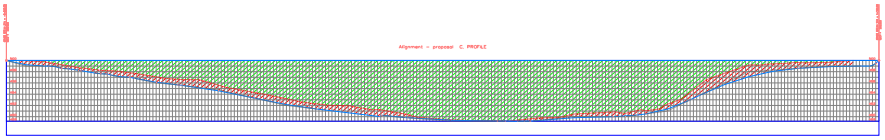

Fig.4.2 Longitudinal profile with Propose fill Embankment volume for Dam Axis C.

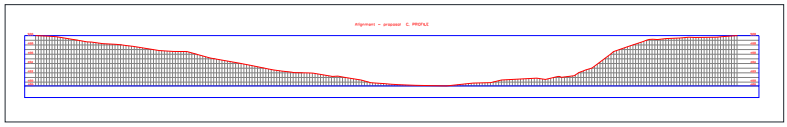

Fig 4.3 Longitudinal profile for Dam Axis C.

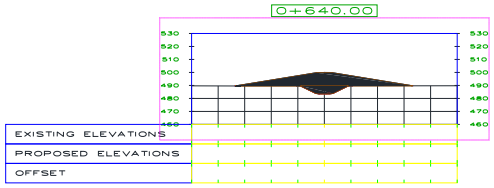

Fig 4.4 Cross sectional view at CH 0+ 640 for Dam Axis C.

Embankment Volume.

The volume for embankment for one of the alternative dam axis calculated using AutoCAD civil 3D is shown in table 4.1 below.

Table 4.1 Embankment volume table for Dam Axis C.

PROPOSAL C Total EMBANKMENT Volume Table						
Station	CUT Area	FILL Area	CUT Volume	FILL Volume	Cumulative CUT Vol	Cumulative FILL Vol
0+020.00	0.00	83.75	0.00	0.00	0.00	0.00
0+040.00	0.00	82.81	0.00	1665.62	0.00	1665.62
0+060.00	0.00	79.97	0.00	1627.83	0.00	3293.46
0+080.00	0.00	78.74	0.00	1587.12	0.00	4880.58
0+100.00	0.00	79.46	0.00	1582.03	0.00	6462.61
0+120.00	0.00	81.09	0.00	1605.49	0.00	8068.10
0+140.00	0.00	83.10	0.00	1641.94	0.00	9710.04
0+160.00	0.00	86.64	0.00	1697.43	0.00	11407.47
0+180.00	0.00	85.96	0.00	1726.02	0.00	13133.49
0+200.00	0.00	87.72	0.00	1736.78	0.00	14870.27
0+220.00	0.00	87.20	0.00	1749.16	0.00	16619.43
0+240.00	0.00	88.12	0.00	1753.22	0.00	18372.65
0+260.00	0.00	91.52	0.00	1796.40	0.00	20169.05
0+280.00	0.00	94.98	0.00	1865.02	0.00	22034.08
0+300.00	0.00	89.76	0.00	1847.41	0.00	23881.49
0+320.00	0.00	85.98	0.00	1757.39	0.00	25638.88
0+340.00	0.00	86.54	0.00	1725.27	0.00	27364.15
0+360.00	0.00	88.29	0.00	1748.30	0.00	29112.45
0+380.00	0.00	89.99	0.00	1782.80	0.00	30895.26
0+400.00	0.00	89.68	0.00	1796.76	0.00	32692.02
0+420.00	0.00	88.15	0.00	1778.29	0.00	34470.31
0+440.00	0.00	86.97	0.00	1751.13	0.00	36221.44
0+420.00	0.00	88.15	0.00	1778.29	0.00	34470.31
0+440.00	0.00	86.97	0.00	1751.13	0.00	36221.44
0+460.00	0.00	87.13	0.00	1740.99	0.00	37962.43
0+480.00	0.00	88.07	0.00	1752.09	0.00	39714.52
0+500.00	0.00	92.52	0.00	1805.97	0.00	41520.49
0+520.00	0.00	91.90	0.00	1844.24	0.00	43364.73
0+540.00	0.00	89.53	0.00	1814.29	0.00	45179.02
0+560.00	0.00	86.57	0.00	1760.94	0.00	46939.96
0+580.00	0.00	83.65	0.00	1702.19	0.01	48642.15
0+600.00	0.00	78.43	0.00	1620.85	0.01	50263.01
0+620.00	0.00	73.07	0.00	1515.02	0.01	51778.03
0+640.00	0.00	72.40	0.00	1454.68	0.01	53232.70
0+660.00	0.00	71.36	0.00	1437.56	0.01	54670.27
0+680.00	0.00	71.02	0.00	1423.83	0.01	56094.09
0+700.00	0.00	70.74	0.00	1417.68	0.01	57511.77
0+720.00	0.00	70.43	0.00	1411.72	0.01	58923.49
0+740.00	0.00	69.73	0.00	1401.63	0.01	60325.12
0+760.00	0.00	71.81	0.00	1415.47	0.01	61740.59
0+780.00	0.00	76.46	0.00	1482.76	0.01	63223.35
0+800.00	0.00	76.91	0.00	1533.76	0.01	64757.11
0+820.00	0.00	74.77	0.00	1516.86	0.01	66273.97
0+840.00	0.00	77.15	0.00	1519.19	0.01	67793.15
0+860.00	0.00	81.47	0.00	1586.15	0.01	69379.30
0+880.00	0.00	82.52	0.00	1639.86	0.01	71019.16

0+880.00	0.00	82.52	0.00	1639.86	0.01	71019.16
0+900.00	0.00	84.01	0.00	1665.25	0.01	72684.42
0+920.00	0.00	83.53	0.00	1675.37	0.01	74359.79
0+940.00	0.00	82.30	0.00	1658.29	0.01	76018.08
0+960.00	0.00	83.75	0.00	1660.46	0.01	77678.54
0+980.00	0.20	79.30	2.00	1630.44	2.00	79308.98
1+000.00	0.00	87.86	2.00	1671.60	4.00	80980.58
1+020.00	0.01	89.05	0.12	1769.15	4.11	82749.73
1+040.00	0.00	102.61	0.12	1916.59	4.23	84666.32
1+060.00	0.00	112.80	0.00	2154.08	4.23	86820.40
1+080.00	0.00	109.81	0.00	2226.14	4.23	89046.54
1+100.00	0.00	108.64	0.00	2184.49	4.23	91231.03
1+120.00	0.00	110.61	0.00	2192.51	4.23	93423.54
1+140.00	0.00	99.41	0.00	2100.24	4.23	95523.78
1+160.00	0.00	94.06	0.00	1934.76	4.23	97458.55
1+180.00	0.00	90.12	0.00	1841.83	4.23	99300.38
1+200.00	0.00	88.37	0.00	1784.91	4.23	101085.29
1+220.00	0.00	85.42	0.00	1737.91	4.23	102823.21
1+240.00	0.00	84.38	0.00	1697.99	4.23	104521.20
1+260.00	0.00	86.02	0.00	1703.98	4.23	106225.18
1+280.00	0.00	88.63	0.00	1746.53	4.23	107971.71

15 Reservoir Capacity. The reservoir capacity shoreline for alternative C dam axis computed at propose spillway crest elevation is shown above.

Table 4.2 Dam Axis C Stage Storage Table.

STAGE STORAGE TABLE						
ELEV	AREA (sq. m)	DEPTH (m)	AVG END INC. VOL. (cu. m)	AVG END TOTAL VOL. (cu. m)	CONIC INC. VOL. (cu. m)	CONIC TOTAL VOL. (cu. m)
490.00	0.01	N/A	N/A	0.00	N/A	N/A
491.00	73.73	1.00	36.87	36.87	N/A	N/A
491.00	1,288.19	0.00	0.00	36.87	N/A	N/A
491.00	4,508.49	0.00	0.00	36.87	N/A	N/A
491.00	93,912.76	0.00	0.00	36.87	N/A	N/A
492.00	243.73	1.00	47078.25	47115.12	N/A	N/A
492.00	643.36	0.00	0.00	47115.12	N/A	N/A
492.00	186,430.16	0.00	0.00	47115.12	N/A	N/A
493.00	2,744.51	1.00	94587.34	141702.45	N/A	N/A
493.00	245.92	0.00	0.00	141702.45	N/A	N/A
493.00	386.66	0.00	0.00	141702.45	N/A	N/A
493.00	3,804.85	0.00	0.00	141702.45	N/A	N/A
493.00	487,068.75	0.00	0.00	141702.45	N/A	N/A
494.00	103.58	1.00	243586.17	385288.62	N/A	N/A
494.00	19,724.48	0.00	0.00	385288.62	N/A	N/A
494.00	1,014,605.32	0.00	0.00	385288.62	N/A	N/A
495.00	1.81	1.00	507303.56	892592.18	N/A	N/A
495.00	77.15	0.00	0.00	892592.18	N/A	N/A
495.00	2,336.52	0.00	0.00	892592.18	N/A	N/A
495.00	1,145.46	0.00	0.00	892592.18	N/A	N/A
495.00	9,190.22	0.00	0.00	892592.18	N/A	N/A
495.00	1,485,935.48	0.00	0.00	892592.18	N/A	N/A
496.00	1,303.29	1.00	743619.38	1636211.56	N/A	N/A
496.00	4.84	0.00	0.00	1636211.56	N/A	N/A
496.00	22,708.46	0.00	0.00	1636211.56	N/A	N/A
496.00	589.49	0.00	0.00	1636211.56	N/A	N/A
496.00	169,505.06	0.00	0.00	1636211.56	N/A	N/A
496.00	4,428.43	0.00	0.00	1636211.56	N/A	N/A

497.00	20,721.08	0.00	0.00	2294166.49	N/A	N/A
497.00	148,629.22	0.00	0.00	2294166.49	N/A	N/A
497.00	531.98	0.00	0.00	2294166.49	N/A	N/A
497.00	34,166.12	0.00	0.00	2294166.49	N/A	N/A
497.00	16,114.79	0.00	0.00	2294166.49	N/A	N/A
497.00	6,787.37	0.00	0.00	2294166.49	N/A	N/A
497.00	1,662.09	0.00	0.00	2294166.49	N/A	N/A
497.00	155,744.53	0.00	0.00	2294166.49	N/A	N/A
497.00	109,490.23	0.00	0.00	2294166.49	N/A	N/A
498.00	3,886.47	1.00	56688.35	2350854.84	N/A	N/A
498.00	4.79	0.00	0.00	2350854.84	N/A	N/A
498.00	74.79	0.00	0.00	2350854.84	N/A	N/A
498.00	13,558.99	0.00	0.00	2350854.84	N/A	N/A
498.00	0.00	0.00	0.00	2350854.84	N/A	N/A
498.00	46,957.19	0.00	0.00	2350854.84	N/A	N/A
498.00	1,767.49	0.00	0.00	2350854.84	N/A	N/A
498.00	147.71	0.00	0.00	2350854.84	N/A	N/A
498.00	606.28	0.00	0.00	2350854.84	N/A	N/A
498.00	37,952.13	0.00	0.00	2350854.84	N/A	N/A
498.00	11,694.69	0.00	0.00	2350854.84	N/A	N/A
498.00	0.00	0.00	0.00	2350854.84	N/A	N/A
498.00	2,474.98	0.00	0.00	2350854.84	N/A	N/A
498.00	94,450.00	0.00	0.00	2350854.84	N/A	N/A
498.00	6,243.76	0.00	0.00	2350854.84	N/A	N/A
498.00	3.30	0.00	0.00	2350854.84	N/A	N/A
498.00	78.00	0.00	0.00	2350854.84	N/A	N/A
498.00	65.80	0.00	0.00	2350854.84	N/A	N/A
498.00	144.76	0.00	0.00	2350854.84	N/A	N/A
498.00	2,668.69	0.00	0.00	2350854.84	N/A	N/A
498.00	0.00	0.00	0.00	2350854.84	N/A	N/A
499.00	794.19	1.00	397.10	2351251.94	N/A	N/A
499.00	25,063.09	0.00	0.00	2351251.94	N/A	N/A
499.00	17,980.74	0.00	0.00	2351251.94	N/A	N/A

Storage Ratio.

The storage ratio for the three alternative Dam axis computed is shown in table 4.3 below.

Table 4.3 Alternative Dam Axis Storage Ratio.

Alternative Dam axis	Storage Ratio
C	16.52
C1	4.59
C2	13.73

DISCUSSION.

Embankment volume.

The results of the alternative dam axis volume of embankment shows alternative C1 have the highest value of 240,232.06m3 with alternative C. With lowest value of 107,972.71m3.

Reservoir Capacity.

From the reservoir capacity results it shows alternative C and C2 having the highest value of 23,50854.84m3 with C1 having 11,03,797.83m3 as lowest.

Storage Ratio.

The storage ratio results indicate alternative C with highest storage ratio of 16.52, followed by C2 = 13.73 and lastly C1 = 4.59. from the results alternative C and C2 have the site rating of excellent The two alternative will be considered for propose Dam axis. Base on consideration of reservoir capacity requirements from demand curve and mass inflow curve interpolation, axis reservoir capacity that equals Demand capacity will farther be considered.

RECOMMENDATION AND CONCLUSION.

a. There are recommendations for a necessity of supporting the selected locations with other required studies, such as collecting geological, geotechnical, and geophysical data to complete this study work.
b. The AutoCAD Civil 3D 2019, using dynamic modelling capabilities is carried out to identify the best dam axis locations and it found to be an economical tool for such study, it usage should be adopted.
c. The results are depending on the accuracy of topographical contour map data result.
d. Finally, the existing Results obtained indicate that careful selection of the dam axis locations base on the contours data with analysis from AutoCAD civil 3D saves time and cost than other studies that spend more effort and time to evaluate best locations.

REFERENCE.

A.M Abdelwaha and M.A Rashwan 2020, "preliminary investigations for choosing the best locations of the Dams using High - Resolution satellite imagery and GIS modelling". Research, volume 9, issue 09 Sept. 2020.

Auto Desk Autocad Civil 3D, 2009 "Road Rehabilitation and construction".

Design of small Dams, 1987. "United States Department of the interior, bureau of Reclamation.

Francois Koenig and David Wong, 2007 "differential Global positioning system (DGPS) Operation and post - processing method" ARL-TN-June 2007, 0281.

ICOLD (International commission on large Dams) 1986 Vol 1, PP 33-47.

ICOLD, 1987, Dam safety Guidelines Bulletin 59.

Olavisi, Ganiyu, m and Moroof, 2012 "preliminary investigations of a proposed Dam site along River One, Ago Iwoye south western Nigeria" journal of science and technology June 2012.

SANCOLD, August 1989, interim Guidelines on free board for Dams south African National Committee on large Dams, Report No.3

Sagadah, B.H., Tayeb, O.M.; Al-sarrani, A.S and Hussein, M.T (1997). "Dam site investigation, a graduation project facility of Earth science, king Abdulaziz university jeddah, Saudi Arabia PP. 71.

Thomas, HH, 1962. "Engineering of large Dams

Tim Stephens, 2010. "Manual on small earth Dams".

Wakuti consulting Engineers Germany,1978,. "Dallaje Dam Design Report. ".