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Optimization of Design Work-Flow of Land Development Project Using Multiple Software Integrations

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Abstract: ***Kasarsai City (K-CITY) is intended to attract multiple industry types: upstream and downstream Oil & Gas, petrochemicals, power and water. The master plan of K-CITY recognizes the operation needs of these industries and has allowed for appropriate infrastructures, roads, IT Parks, logistics, commercial and residential areas and highly specialized training centers to complement and enhance the use of the overall community while contributing to the health, welfare and quality of life of its residents. So, the workflow of land development of project K-CITY of entire project has been demonstrated including site selection, preparation of master plan, site grading, utility design and road design.***

Keywords: AutoCAD, Civil 3D, SketchUp, Infraworks, Navisworks Freedom, Lumion, Google Earth Pro, Land Development

1. Introduction

The design phase is considered to be one of the most challenging processes as it is concerned with the creativity and efforts of human minds to create, innovate, test, and transform ideas and inputs into value-adding services, products, or facilities for clients or end-users. Any deficiencies and complications resulting from design can have detrimental impacts throughout the project's life cycle. The highest levels of effort and influence on the project are attributed to the early design stage whereas the cost of changes is the least during early design.

So, to define a design workflow of Land Development Projects we have chosen a Land for its Infrastructure Development. We have named that Project as K-CITY, which is located at Kasarasai, Pune, India. (Refer **Figure 1: Project K-CITY Location**)

The global position of the site is at about 18°38'N 73°39'E. The site is about 963 acres (including the small portion of land which is already in use as an RMC plant and One D-Mart Warehouse) located on the outskirts of the town of Kasarsai and Chandkhed. Another remaining part of Land is in agricultural use. This Project site location is consisting of a total area of 3.19 Square Kilometers which considers Infrastructure Development. This project is initiated for optimization of design workflow of Land Development Project using multiple software Integrations. To determine the Design workflow of the Project we have considered a small mix-use Township dedicated to Energy-related Industries that will develop into a global energy hub near Pune in an area located around 25.6 kilometers South-East Pune.

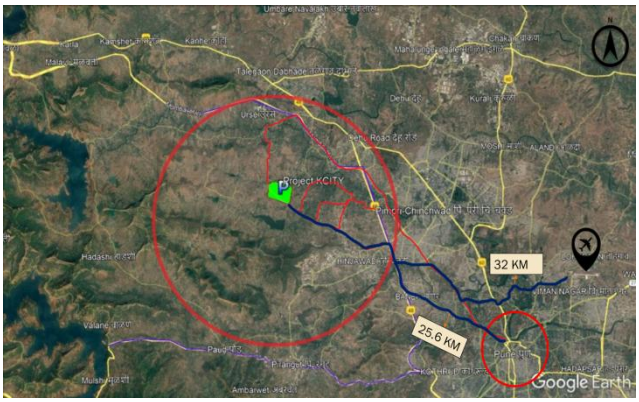


Figure 1: Project K-CITY Location

1.1 Key Objectives

The Objectives of this Project are listed below:

- Apply basic engineering tools, such as statistical analysis, computer models, design codes and standards, and project monitoring methods.
- To provide infrastructure in harmony with the existing site environment as well as the proposed Master Plan.
- To provide a coordinated plan with identified interfaces between utilities as well as well-defined tie-in points with the external utility sources and building plots.
- Brainstorm how can we improve underground utility modeling in future releases of Infra-Works and AutoCAD Civil 3D.

1.2 Project Scope

We will prepare consultancy services for the planning, concept and preliminary design, detailed engineering, and preparation of construction drawings for the following utilities by using multiple software integrations:

a) Cut-Fill & Site grading
b) Design of Roads (Geometrical design, Road Alignments, Corridors, etc.)

c) Design of Wet Utilities
- Water
- Stormwater
- Irrigation water
- Sewer Water
- Firewater

d) Design of Dry utilities
e) Conceptual Modelling

This report is the Infrastructure Assessment Report for the office and Industrial building included in 963 acres development at the outskirts of Kasarsai and Chandkhed Village.

2. Detail Methodology

Assumptions:

- Working on only one building from each zone and will be demonstrate the same for the other part of respective zone.
- Working on office and Industrial Building Land Development only.
- Taking all the Input data as per CPHEEO for Utility Design and IRC Standards for Road designs.

Designing Process:
As we were defining a design workflow of Land Development Project using multiple software Integration, we have split the design workflow into different steps as follows:

2.1 Detail Topographical of the sites by using QGIS and Google Earth Pro Software.

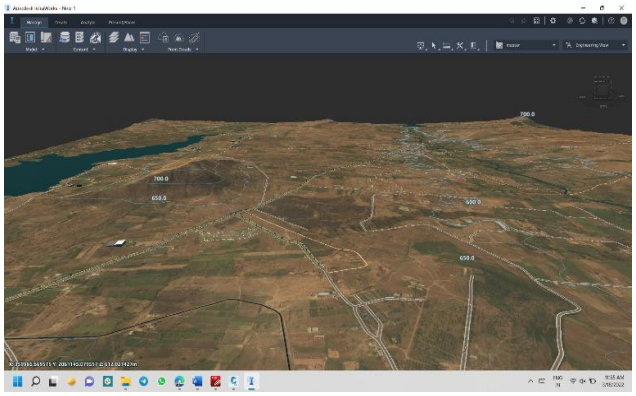


Figure 2: Infraworks Model

2.2 Preparation of Master Plan for the Area by using AutoCAD and SketchUp Pro software

Figure 3: Master Plan

Site Preparation & Site Grading using **Civil 3D**software.

Land use:
All Land has been divided into different zones as per master planning including Office building, Educational Building, Industrial building, Residential and commercial building as main zones.

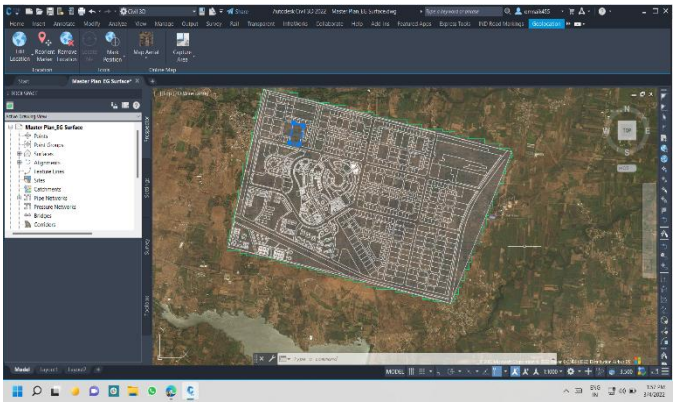


Figure 4: Optimization of Site Location

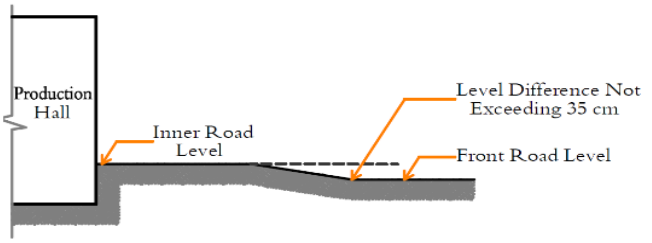
The guidelines apply to the following planning and design activities:

- Site Design
- Grading
- Storm Drainage

The Civil Site Plan will dictate the floor elevation of all buildings on all sites.

The grades on sites shall be designed from the elevation of surrounding roads into the sites to provide for adequate drainage. Appropriate software such as civil 3D shall be used to grade the site and the philosophy of design shall be as follows:

- Surrounding road designs shall be completed first.
- Floor elevation of buildings shall be designed from the elevation of open channel utilities which the site shall connect to, such as sanitary sewers and storm drainage pipes.



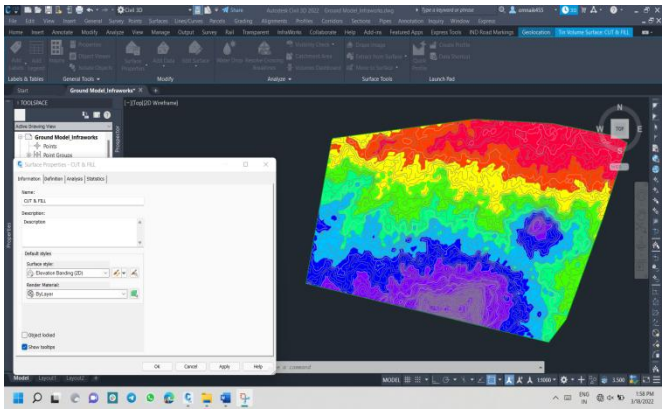


Figure 5: Cut-Fill & Site Grading

2.3 Detail designs of Roads network (Geometrical Design, Road Alignments, Corridors, etc..) using Civil3D and Infraworks 360

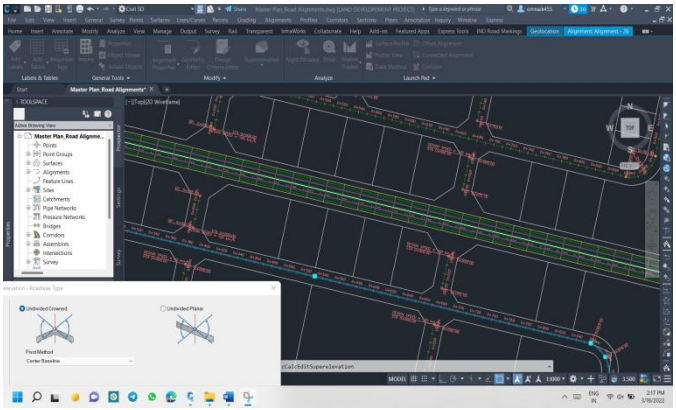


Figure 6: Road Alignment & Corridor Preparation

Design Details

2.3.1Roads:

2.3.1.1 Geometric Features for Internal Roads

"IRC: 86-1983 - Geometric Design Standards for Urban Roads in Plains" guidelines will be used for the design of geometric features of roads (i.e. sight distance, horizontal and vertical alignments), pedestrian facilities, At-grade intersections (IRC: SP: 41-1994), turning radius at intersections and medians to provide optimum efficiency in traffic operations with maximum reasonable cost. For the proposed township, the internal road network geometric features will be designed for Single unit truck having following dimensions and turning radius values.

2.3.1.2Design Speed

As the roads in proposed development will have mostly slow-moving traffic, cross movement of traffic and also pedestrian traffic, a design speed of 30 KMPH is proposed for the site.

(i) Cross Sectional Elements:

- Camber / Cross Slope
- A camber of 2% is recommended.

(ii) Stopping Sight Distance:

For the proposed design speed of 30 KMPH the required stopping sight distance is 30.00m.

2.3.1.3 Horizontal Alignment Details (as per IRC:38)

(i) Minimum Turning Radius

As per IRC guidelines the required minimum turning radius for the design speed of 30 KMPH is 35.00 m. At-grade intersections and roads connecting to the adjacent properties, the minimum radius should be provided as per requirement of the design vehicle.

(ii) Super Elevation on Horizontal Curves Super elevation required on horizontal curves should be calculated as per IRC guidelines and it should be limited to maximum value of 7%. The minimum super elevation to be provided on horizontal curve may be limited to the camber of the surface.

2.3.1.4 Vertical Alignment Details (as per IRC: SP:23)

Vertical alignment is governed by need to match the entrance line levels and levels of intersections.

(i) Gradient

As the roads in proposed development will have mostly slow-moving traffic, cross movement of traffic and intersections at regular intervals, in view of this, gradient in the range of 0.20% to 2% are acceptable.

(ii) Vertical Curves

Vertical curves should be provided at all grade changes for smooth transition and movement of vehicle from one grade to another grade. As per the IRC guidelines the minimum length of vertical curves (summit and valley) for design speed of 30 KMPH is 15.00 m.

(iii) Ramps (Vehicular and Pedestrian Ramps)

(iv) Vehicular Ramp

The tangent grades on ramps should be as flat as feasible, and desirably, it should be limited to a maximum of 4%.

(v) Pedestrian Ramp

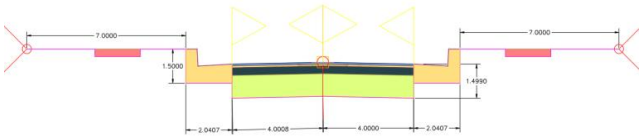
Desirable maximum gradient for pedestrian ramps is 10% (IRC guidelines).

2.3.2 Corridors

As per the guidelines of IRC 86: 1983, the recommended Land widths of Roads, tentative capacities between

Intersections, recommended carriageway width, capacity of footpaths for different zones, safe stopping sight distance & minimum gradients has been taken under considerations for design of corridors in Civil3D.

The recommended corridor has been prepared using different assemblies of Basic lanes, Shoulders, Medians & Curbs.



3. Detail design of Wet Utilities consisting of Storm, Sewer, Potable Water, Irrigation, and Firewater using Civil 3D and Navisworks Freedom for Clash Detection.

This section provides a potable water and Fire water supply detailed design basis for the new Industrial building to support K-CITY Drilling & Workover (D&WO) in the city of Kasarsai in the Northern Eastern Province of the Pune, Maharashtra, India.

Currently, existing facilities are located in Kasarsai. The existing facilities are outdated and at peak capacity and cannot accommodate the anticipated manpower increase which is 600 employees.

New facilities are needed to support the growing activities for D&WO. The new construction will accommodate approximately 600 personnel and will be located in a modern, efficient facility at K-CITY. Potable water will be used to supply the daily water demands through the water distribution system. For protection against fire event a Fire water service mains with hydrants are provided along with additional storage in the water supply underground tank within the Industrial facilities premises.

The calculated water demand was based on the Water Supply Requirements of K-City development standards.

General demand per capita for Industrial facility that were used in calculating the overall water demand of the proposed Industrial facility is listed in the table below

Table 1: Water supply requirement for Industrial building

Description	Amount	Unit
Population	600	Nos.
Floating population	60	Nos.
Total Population	660	Nos.
Per Person Demand	45	Litre/person/day
Average Daily water demand for workers / personnel	29.70	m^3
Total site area of Industrial facility	1.31*	Ha.
Assuming this industry as Low water demand industry Industrial Water use	40#	m^3/ha/day
Industrial facility daily Water Demand	52	m^3
**Total daily Potable Water Demand	82	m^3
Maximum Hourly Demand Factor is	3	
Maximum Peak Hour potable water demand is 3*82.14	246.42	m^3/day

* Area is measured from the Industrial facility layout plan drawing.

** This as per CPHEEO standards.

3.1 Hydraulic Design Calculations

For hydraulic design, the Hazen-Williams head loss formula shall be adopted:

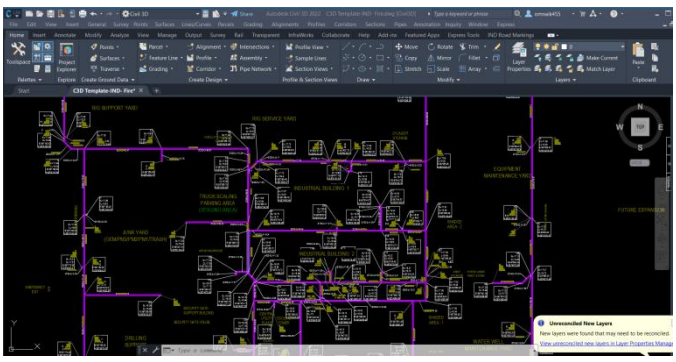
$$Hf = 6.82[(L/D1.17) \times (V/C) 1.85]$$

Where,

Hf = head losses due to friction (m)
C = the friction losses
L = length of pipes (m)
V = Velocity m/s
g = acceleration due gravity m/s^2

Currently the Fire water main is designed for 1500 GPM of flow rate-based with minimum pressure for Hydrant of 20 psi SBC-801-CR with flow duration of 2 hours. The pipe network that will supply the Firewater is proposed to be of 250mm ring main and branch connections to FH and Buildings will be of 200 mm and 150mm so that it can carry 1250 GPM of flow with velocity less than 2.3 m/s.

The external water supply main which will connect to the internal office building plumbing system is designed of 110 mm HDPE pipe which will carry an average flow of 82.1 m3/day and a minimum residual head of 48 mH_2Ois kept at the ground so that the minimum residual head at the top floor of the building will be 30 mH_2O.



The steady-state model was developed and verified against the following hydraulic criteria:

- Minimum residual pressure provided is 30 m.

- Maximum velocity is restricted to 2.3 m/s.

Below illustrates the water supply main transferring water from UG tank to Industrial building and Proposed Tapping line from tapping points to UG tank respectively.

Table 2: Hydraulic summary of water supply network

Pipe size (mm)	Material	Length (m)	Velocity (m/s)
90	HDPE	1045	< 2.3
*355 *It is external tapping line*	HDPE	2	< 2.3

Below illustrates the Fire water main connecting and transferring water from UG tank to Office building and its surrounding premises.

Table 3: Hydraulic summary of Fire water main network

Pipe size (mm)	Material	Length (m)	Velocity (m/s)
250	HDPE	3578	< 2.3
200	HDPE	426	< 2.3
150	HDPE	60	< 2.3

Table 4: Irrigation Water requirement

Description	FAO recommendation	Design recommendation
Trees	60 L/T/d	90 L/T/d
Grass	11 L/m²/d	20 L/m²/d
Shrubs	7 L/m²/d	11 L/m²/d

We have taken 20L/m²/d water rate for landscape area.

Table 5: Hydraulic summary of irrigation water supply network

Pipe size	Material	Length (m)	Velocity (m/s)
110	HDPE	200	< 1.5
90	HDPE	1232	< 1.5

4. Conceptual Modelling / 3D Visualization of Entire Project using Infraworks-360, Twin motion, and Lumion 10 software.

Figure 7: 3D Modelling using Infraworks, Lumion &Twin motion

Expected Outcome

a) Helps in Project planning and execution of quality control programs for civil Infrastructure Projects.
b) To provide consultancy services for the planning, concept and preliminary design, detailed engineering for the following utilities:
   - Roads and Site Grading
   - Storm-water management
   - Water supply systems
   - Sewer water
c) Helps in Project Planning and management for civil and multi-discipline projects.
d) Gives an idea about reliable and safe engineering design with identified risks and mitigation.
e) Comparative study of Land Development projects with Software Design and without software Design.

5. Conclusions

All the drawings regarding Road, Utilities containing Water, Sewer, Storm, Fire and Irrigation network has been prepared as per design criteria. Applied basic engineering tools, statistical analysis and software's to demonstrate the entire workflow of Project K-CITY. All Roads, corridor, site grading, Utilities of the Industrial and Office Building facility has been designed as per standards and some of assumptions taken in considerations.

This is how we have demonstrated the design process of Land Development of project K-City.

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