COMPARISON OF COMPLEMENTARY DESIGN BETWEEN DIFFERENT ERAS

Written by:

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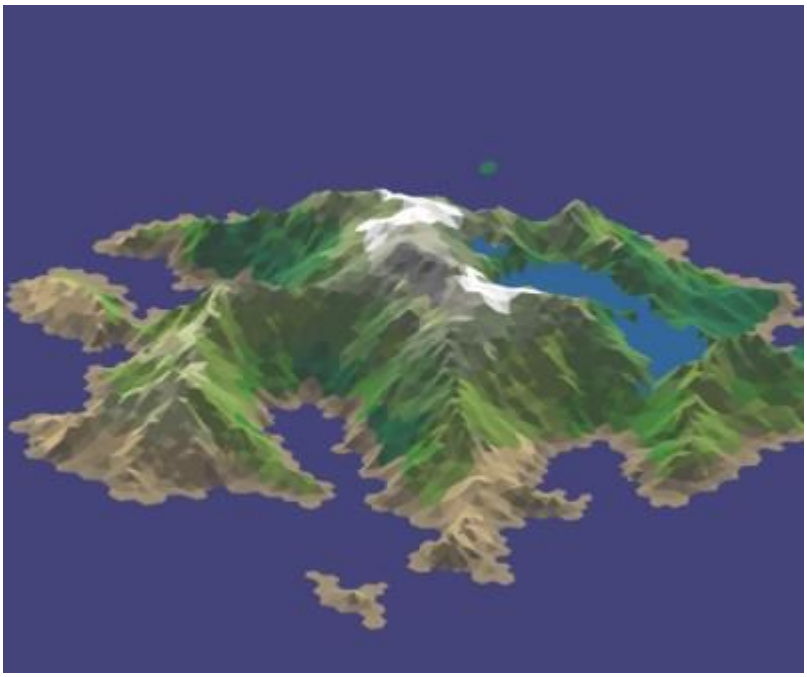
December 2021



Comparison of complementary design between different Eras

- Abstract
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Abstract:

In every developed country and specially nowadays, the effort is not saved to design engineering structures starting from infrastructure to buildings, electrical and mechanical projects, this for sure covering manufacturing and IT projects in addition to water related projects,, transportation projects, and here I am focusing on the transportation sector and this study will try to compare between design steps conducted for roads water and sewerage and comparing to the current steps using new engineering software such as Auto cad product such as Land development and Civil 3d software, while these programs created in specific for this purposes and consisting many features, purposely in here we will compare the advantages and disadvantages of both the design aspects, and will give pure idea about engineering technology, program and how it reflected on work and engineers performance.

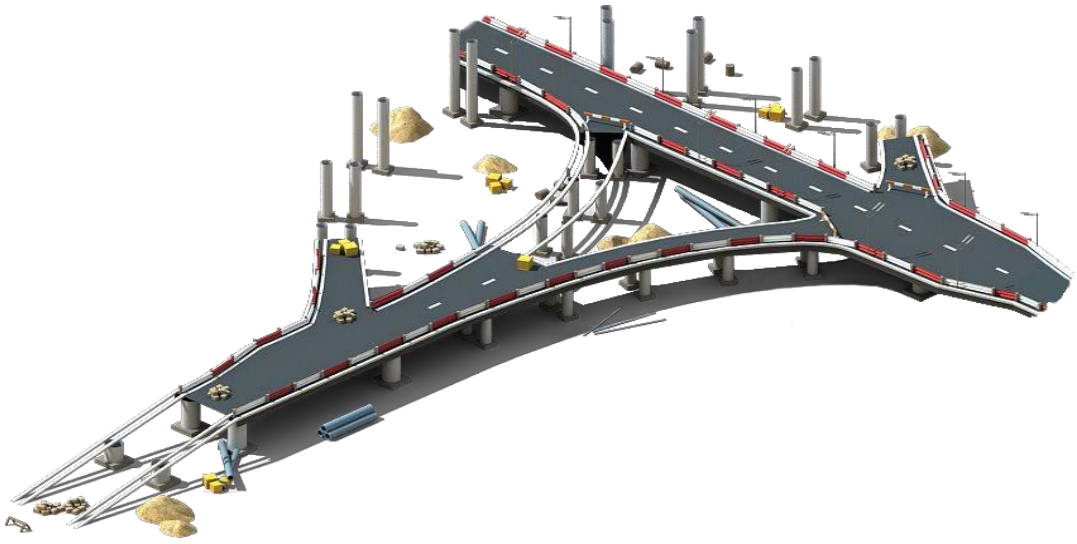


Figure 1 Construction of a bridge

Project management stages:

Beside of specialty of engineering civil, architect, mechanical, electrical, environment and other part of engineering, under the same above-mentioned category there are many other specialties where skill helping and serving high number of beneficiaries and support other structures, at the same time helping many stakeholders.

Generally, for each construction project there are gradual broke downing process to stages some resources saying four and others five main stages, firstly, is the feasibility study and initiation, the second planning stage, then implementation and the last but not the least is closuring of the project.

Every construction project, regardless of size, benefits from a solid plan and a great project manager who is familiar with construction project management. To build the right plan for your construction project it is helpful to understand the construction process.

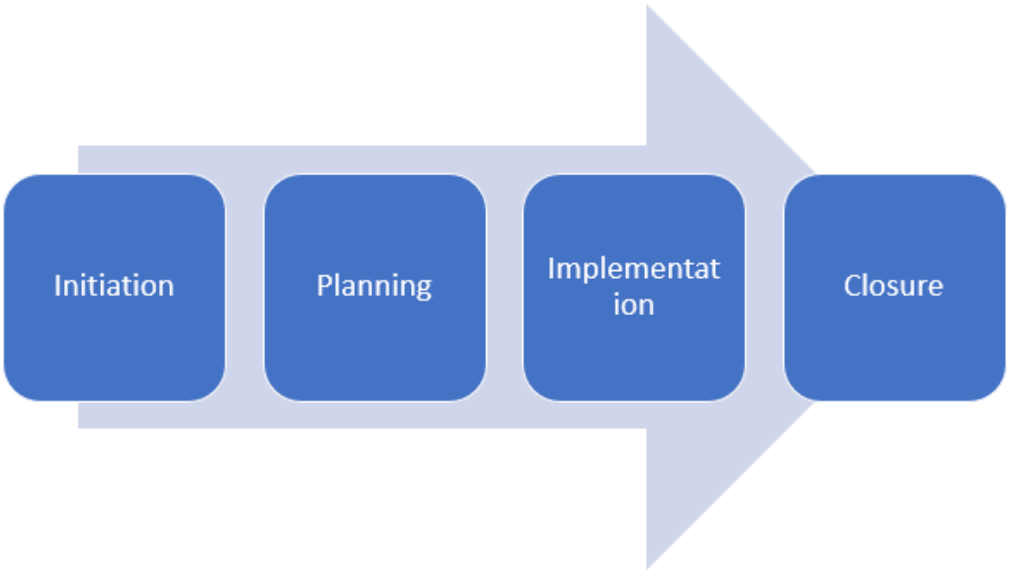


Figure 2 Project management stages

1. **Feasibility study and initiation**

The feasibility study is the procedure to predict outcome of a study, or assessment of a planned project, These studies allow proper investigating and evaluating any production also on the essential requirement to commence the project , this phase show you the domain idea, imagination of the project and its effect on the stakeholders, and how it reflect on the people of locals, in this stage usually not focusing on technical , design portion of the project, but might point out to the main idea of the shape and to some extend the overall basic concepts. For sure within this stage many other studies might be discussed either environmental or social aspect of the project and trying to cover all other parts which are related to this project and over all imagining the age and future of the project and studying the risk at implementation and pro implementation of the project.

The initiation phase is one of the most important aspects of construction project management. It encompasses all the steps you must take before a project is approved and any planning begins.

Before the project starts, a project manager must develop and evaluate the business case to determine if the project is feasible and worth undertaking. Stakeholders may be asked to do their due diligence and to conduct feasibility testing, if needed. When all partners agree to proceed with the project, the project manager writes a project propose or project initiation document (PID), which includes both the project needs and the project case.

Usually in construction project here we are showing graphs, tables, and a clear data for engineers and non-engineer staff, where clarify economical, technical fundamentals.

Figure 3 stakeholders Initiation meeting

2.Planning

Each project needs to be designed and put all the related data of the project on drawing or software to be clarified, in very general terms, design is the reflection of an idea, or the resolution of requirements, through items such as drawings, plans, specifications and models. These can then be used to enable items to be created or issues resolved and shape to be designed, Next, the project team develops a road map for all involved, and totally it covers WBS work break of all the technical and managerial item in the project in a way showing every details clearly and understandable to the field and staff doing implementation.

The process for completing the design and construction of a building is often divided into notional 'stages or phases. This can be helpful milestones, the preparation of information for approval, client gateways, and for making installment.

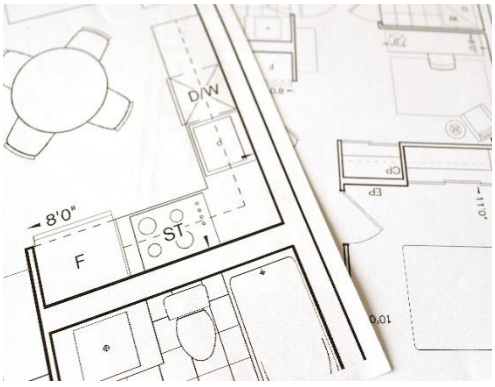


Figure 4 Planning and designing stage

3.implementation phase

To sum up all the previous Two phases and throwback them in fact in the field, this step will call implementation, this is the field work, in constructional project and its work in the program if we are talking about implementing some software or program, because implementation covers wide project, starting from construction, programs, management and many more.

since thousands of years the process of constructing new structure was in these schedule and threshold, all these stage were part and phase to achieve your goal, even people from Mesopotamia and people from ancient Egypt were working on the same procedures, first the pharaoh requested a pyramid for the sake of his mortality to be built for him and his loved family and then his skilled men started to think about a highest place to be built then this is feasibility, then planning will be started on what ground and how to be shaped and how will be implemented, then hard worker working on cutting, Transporting and sorting it to build the great Pyramid which over all together are called implementations phase.

Typically, all parties hold a kickoff meeting, then the project team begins the crucial work of assigning resources, implementing project management plans, setting up tracking systems, completing tasks, updating the project schedule, and if necessary, modifying the project plan.

In addition to this we should some ow monitor the quality and progress for each project and follow each step and comparing it to our design and planned requirement, somehow it called monitoring, and, in some project, it will be accounted as an independent stage of the project, and even the employer in this stage more skilled and better qualified with consultancy experience, the name perhaps changes to consultant or QAQC or manager etc.....

Figure 5 Planning and designing stage

4.Closure phase:

This final phase marks the project's completion. To mark the conclusion, project managers may hold a post-mortem meeting to discuss what parts of the project did and didn't meet objectives. The project team then creates a punch list of any lingering tasks, performs a final budget, and issues a project report.in addition to handing over the projects to the owner or to the responsible partner where it maintains and manage the finalized project, either its public or private sector.

In addition to that for sure there will be warranty period for all project , warranty period is called on the time where the implemented project will be monitored and checked regularly to ensure its workability, the duration of this warranty time will change directly to the change of the project size, and budget in addition of the type of project, for example roads usually its warranty period is long and reaching few years, some building project would be one years and others 6 month and so on.

Basic and previous designing of roads and sewerage

In this study I want to focus on the last Two stage of any project, while feasibility phase usually will be participated by many other specialties other than engineers, for example admins, sociologist, geologist and many other depending on the type of projects and the requested condition.

The second point here to be mentioned is, we are focusing on the project related to infrastructure, which is covering roads, sewerage and water supply system in Specific, trying to cover all the steps contributed in this kind of project, and it all came ups from a point of view as an engineer worked in Kurdistan and Iraq for over 15 years within this specialty, throughout this study I am sharing my experience and showing some photo and drawing by myself and been used for designing purposes specifically medium and small road projects

1. **Surveying**:

When we are talking about roads, we should think about landscape of the natural ground and how the elevations and location affect design and type of roads, for sewerage line and rain inlet are similar as well, in addition to the water supply system where all related with head (elevation) and GPS data, where here surveying will contribute actively.

The history of surveying dates back to ancient times, with a recorded land register in Egypt in 3000BC, and re-establishment of farm boundary following floods of the Nile River and construction of the Great Pyramid of Giza as mentioned previously as well recorded about the same time.

Under the Romans, science of surveying was invented as a specialty and land surveyors established the basic measurements under which the Roman Empire was divided, such as a tax register of conquered lands (300AD).

In eighteenth century more specifically in Europe, a method of surveying known as triangulation, which relied on the measurement of angles, was used to build a hierarchy of networks to allow point positioning within a country, so many tools from then have been invented scientific worked hard to create many scientific ways and equation reinforce the surveying purposes.

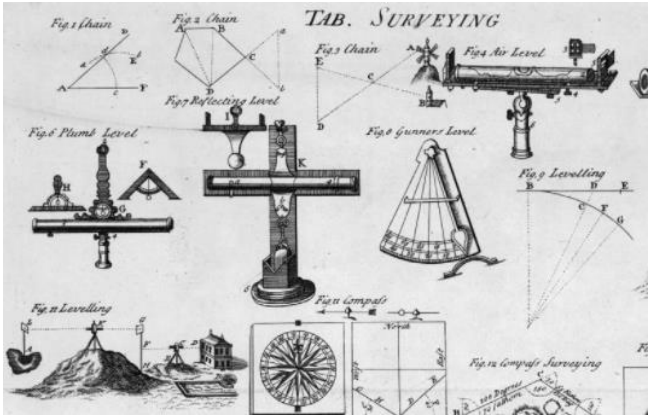


Figure 6 invented survey equipment

As we learned partially from university some others from survey course to use survey for enforcing our project and planning wiser, satisfying our needs depending on the actual available data from field, the most famous tool which was used previously for surveying is level instrument, level was used for determining the elevations of specific area, in addition of some small privilege for measuring distances, horizontal angles and some other minorities, beside of level the second most famous instrument is theodolite, which was little bit more complicated than level instruments but with better and higher ability, for measuring horizontal and vertical angles precisely and actively, these instrument were built in different manufacturer company, with different privileges, but in the result Theodolite was a good and active instrument for long time till this very day.

Now we need to mention other attached tools to this Two above equipment for instance tape, staff, and tripod.

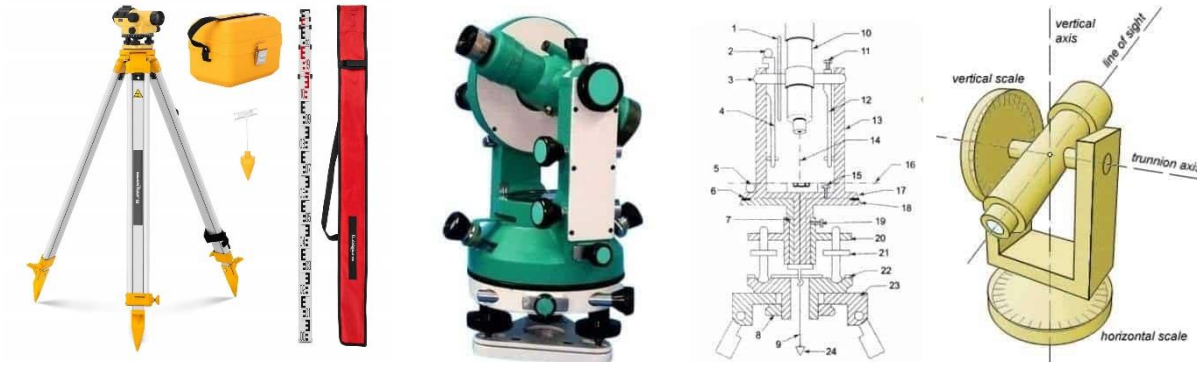


Figure 7 Survey instruments

The above shown instruments, some of them still a critical instrument specially (Level instrument) for daily use very precise and usable for many duties and easy to install, then multitask, and others perhaps used rarely but still they are a basic for future and next Era survey instruments, the usual steps would be done practically on field will change but the main concept and mutual step as shown conducting as bellow:

To get some flexibility about the path of the road we need to have a clear idea about topography of the path and to some extend the adjacent area as you all acknowledge that each road has an alignment, alignment means the path of the road where it passes and needed to be constructed and its usually the centerline of that road at the same time.

For designing purposes, we need to have a clear idea about the topography of the alignment and its area, to give our preliminary design centerline and in case it needs to be dragged or changed in some other situation at this stage we will decide the final path.

Without topography data it will be very hard to decide on the design and the rout of the road as well specially in new established road, and for sure will face many issues and might experience failure in plan, project and economic aspect, in the following steps I am talking about road design in general and in specific urban area roads, some parts are similar to highway design and some not.

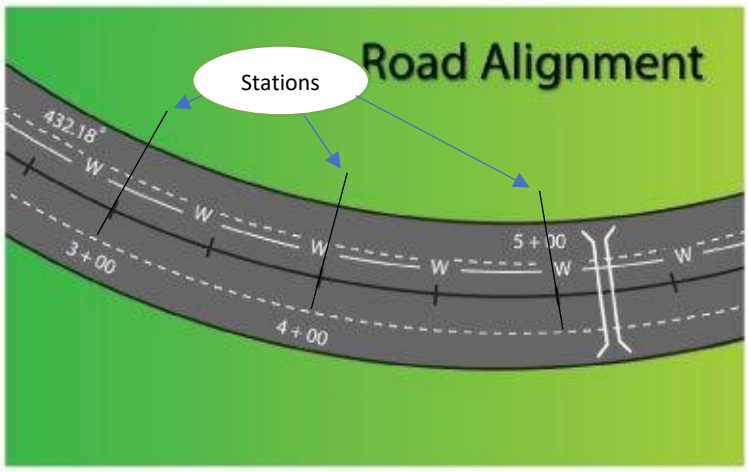


Figure 8 Road alignment

- For making a topography the most common way previously was giving stations station it means any point on the alignment which needs to be named with distance, for example for sure for any alignment we start from station 0+000, then the increment will be changed according to our need either 10m, or 20m 50m etc.., then in 10m increment the next station will be 0+010, 0+020 and so on. distance measuring with manual tapes in very basic way we will specify points with similar interval, this distance will depend on the topography of the road which we are designing, in case steeper or vertically there was lot of sag and crest we will use shorter interval , but in case the road is flat and uniform the distances will be more, at this stage when we decided how long the interval is at field we will specify 0+00 point which it means start point of that specific profile, at the sometime usually it will be the cross point with other profile, then interval process will start by tape measuring (for example here we use 20m interval) and coloring or marking that point on the land, and from now on we will call that at site point as stations and name it as station 0+200. It means the distance from start point to this station is 200-meter length while we use metric dimensions in Kurdistan region

and even in the region, here I should mention in case the width of the road 40 meter over all we need to have points from the sides for instance 40 other meter in each side, this procedure is more common for flat area where all ground activities are easy to be held.

- The other way to be conducted is using Theodolite machine for reading points spontaneously over the alignment pass way in the area reading angles and distances, where it measures distance and elevation over all the alignment then to be recorded.
- In selecting of the points, we will specify some critical point in term of house doors or in case elevations was very high or low, existing sewerage line, existing water supply line, and in any place, there is critical sag or crest, and whatever milestones available and somehow contribute on the design.
- After specifying the interval, surveying will start, level or theodolite will be the major equipment used in this kind of mission, fixing the equipment in a place were covering as much as possible point on the road including the houses.
- These all data will be calculated at office and collected to give you a topography of the mention area where it shows almost a clear image of the area, and for sure the final handmade or AutoCAD would be as the following: -

There is one point we should clarify here, in case we are working in urban area its better to have the topography over all the area, because all the roads within urban area are connected to each other and should be take it all as one package.

NB: the following topography is useful for giving you the over all slope of the area and where is sewerage and storm directions.

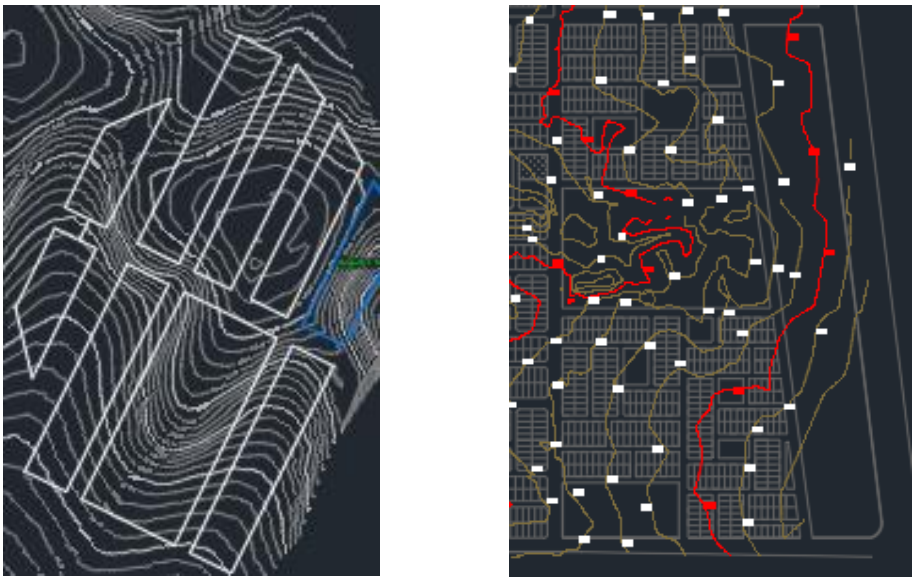


Figure 9 Piramagroon Project topography

2. **<u>Desk work and designing</u>**

- Office work will start to determine and calculating the data from the survey and collecting all these numbers and elevation on a booklet, we can say having topography is critical thing and will show and contribute in establishing a good imagination of water flow and how sewerage and rain flood going, at the same time it affect the design of the road basically but still topography is not everything but a base for almost all the other following steps.
- In case we already have houses in the area or, only a piece of land we need to have the houses or at least the planned map as a reference over that topography to distinguish the roads needed to be designed, after specifying it we clearly know how to choose the alignments of the work.

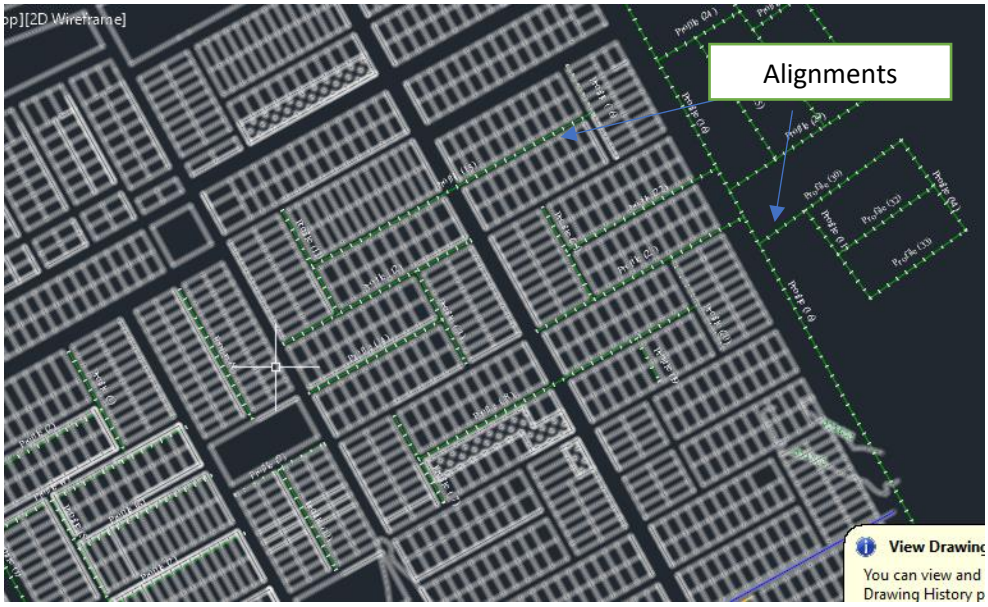


Figure 10 Alignments

This alignment will be the base for the next step for creating profiles.

- Drafting by using AutoCAD or manually will be next step by drawing the longitudinal profile, the vertical vector showing the elevation with intervals depending on the Hight differences and scale 1:10 is the common scale regarding elevation, the horizontal vector showing stations and distances usually vertical scale 1:100 Horizontal scale 1:1000 is the common scale.

Figure 11 Typical longitudinal natural ground profile

- Transporting all the data from the survey and on the booklet to the drawn profile each station has its elevation, then each point will show one natural ground elevation, connecting these points will show all the natural ground profile for that road, still till this stage we do not have any design and useless for implementing a project, because its only showing the real existing natural ground symbolized as ENG or NG.

  As its clear from (Figure 11) the vertical vertex showing elevation from sea level, the horizontal one showing both station and showing the accurate elevation of that specific station in the ban to be clearer.

- Then design step will be started, after combining all the data and imaging then imagining all the element on one drawing then the design step will be started by drawing lines over the natural ground in a way minimum cut and fill will be created , first for economic reason second for time spending on the project, the drawn line when crossing then it will be either sag or crest , sag will be similar to a swamp and crest will look like a hill , in both condition in the drawing it will show with curve and the diameter of the curve should be known. The drawn line slopes should be according to the municipality condition, for example in Sulaymaniyah municipality when the slope over than 5% then concrete road should be designed, less than 5% it should asphalt road will be required, somehow, we can say at this stage we have a designed road.

- To show the designed elevation in the profile, one line under the horizontal vector will be added which is showing the design level of the road and it is common to be the elevation of the final subbase layer.

- The other step will be the unifying steps, each profile s start and end point, and those point might cross other line or roads, so at this step all this cross point including start and end points should be unified, in term of natural ground N.G and design level, this is one of the important steps should be checked regularly.

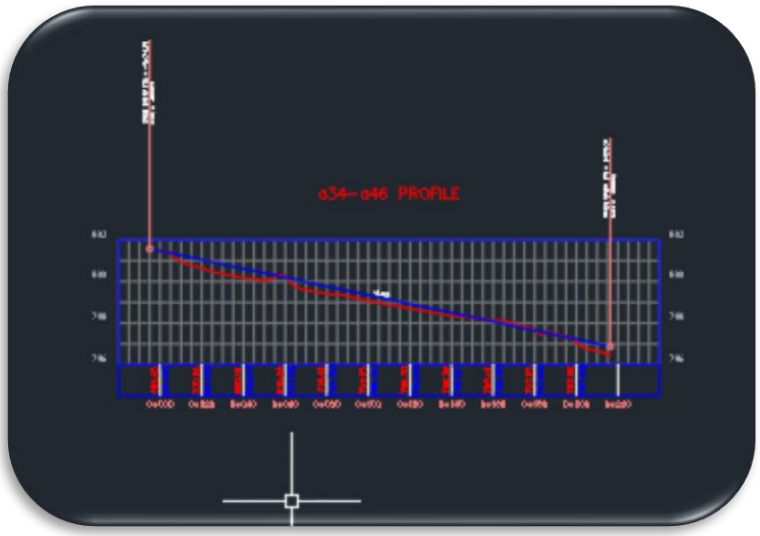


Figure 12 Typical longitudinal profile showing natural ground and final designed profile

The red line showing NGL, and the Blue one showing designed subbase level FDL, and the road slope with white color as shown in the Figure number (12)

Then after this step we can say we have a good designed longitudinal profile with its all elements, from now we can discuss about sewerage and water inlet designs as shown in the next part.

3. **Sewerage design:**

Someone might ask, can we design sewerage lines before designing the road?

And think about it and be curious about it, for sure my answer will be this (it's better to work on sewerage design after finalizing road design) and my justification for this is , while the final level of the roads not clear we might design the sewerage high or low , in both conditions it's not good idea, in case it was high the individual house sewerage lines might be lower and not discharging the sewage to the line, and in contrary in case it was low, usually it needs more work, budget, and unnecessary manhole sizes, which we come back to this subject precisely later.

So after completing the road design everything is ok and we can continue to the next step for designing the sewerage lines, the design level is our reference for determining the level of the sewerage lines, in each country there are some standard showing in detail how we are working on sewerage lines, for example showing us the standards for calculating rain, the depth of pipes, type of pipes, standard for

type of manhole, Rain inlet dimensions, manhole cover dimensions, how to do filling around manhole and pipes, those and much more.

In USA even it changes according to the states, Germany has its standard for each, and all part of the road design and sewerage called DWA and DIN, its similar for whole Europe and other developed country.

Unfortunately, in Iraq and Kurdistan sewerage systems are combined it means sewerage and rainfall are accounted together and using one sewerage line for both, which somehow against environment. Even so we did some proposal for designing separate sewerage systems.

Generally, the design start after accounting the sewerage amounts comes from the houses or any other building available in the area and producing sewerage, such as school, hospital residents and shops all for sure has its standard and its changes according to the country and even cities.

In addition to the rainfall in here we mentioned that usually there should be some standard of precipitation depth standard for that area.

- Equation for accounting flood amount is very simple, area was collecting rain and feeding that pipe* by precipitation depth= catchment area*i
- Equation of sewerage amount is manning equation

$$Q = VA = \left(\frac{1.49}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [U.S.]$$

$$Q = VA = \left(\frac{1.00}{n}\right) AR^{\frac{2}{3}}\sqrt{S} \quad [SI]$$

Q= total discharge of the sewerage and will be calculated from residents and source of sewerage providers and building consuming water, flow rate.

V=Velocity

A=Flow area

n=Manning roughness coefficient

R=hydraulic radius

S=pipe slope

We are not going in detail regarding accounting these amounts, because it is independently needs to be clarified in a different study.

At this stage where we have the discharge, we can decide on the pipe diameter in according of the existing pipeline slope, and the type of pipes were usually in that time were either concrete pipe or box sewerage.

And the final shape of the profile would be as the following figure, where it shows the pipe lengths, slope diameter.

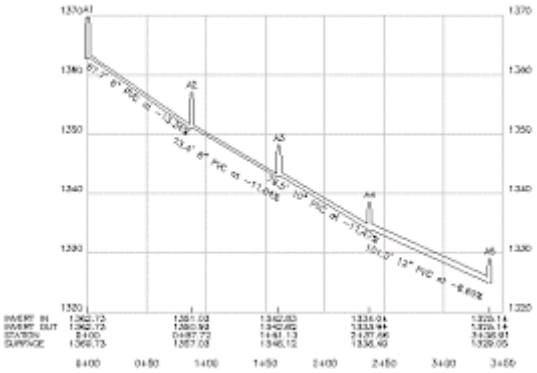


Figure 13 Typical profile showing sewerage line

Basic and Current designing steps using contemporary software:

From now on we will start to present a new way for designing and current steps for the same purpose, in here we try to show and clarify with the same stages as before which already some rout but enforced with some technical and updated equipment, to compare easily between both era and give an image for new engineer generation and old generation at the same time, for new generation to ease the way for creating new infrastructure designer , and for old generation to clarify and update them with those science and technology for empowering skilled engineers skill.

1. **Surveying**:

For surveying reason purpose and to create an image of specific area and to produce a topography recently there are many new updated equipment such as total station which is updated version of Theodolite, GPS and drones respectively.

All these equipment is very new updated, using for the purpose of collecting all the data effectively, the technic of these is totally different from the other previous one, in all the three equipment we will choose spontaneous points from the land and as much as the distance between two points closer the much precise, for sure more effective and accurate, the equipment is showing in the next figure:

Total station GPS Survey drone

Figure 14 New survey equipment

After getting all the point reading from the land we will save all in the memory of those equipment and usually handwriting not necessary except rare condition. All these points by each equipment will be saved in a file.
This file can be returned in many kinds of files starting from txt, accdb and others. At this stage we can say we have only a file can be originated to computer and covering all the points we already surveyed.

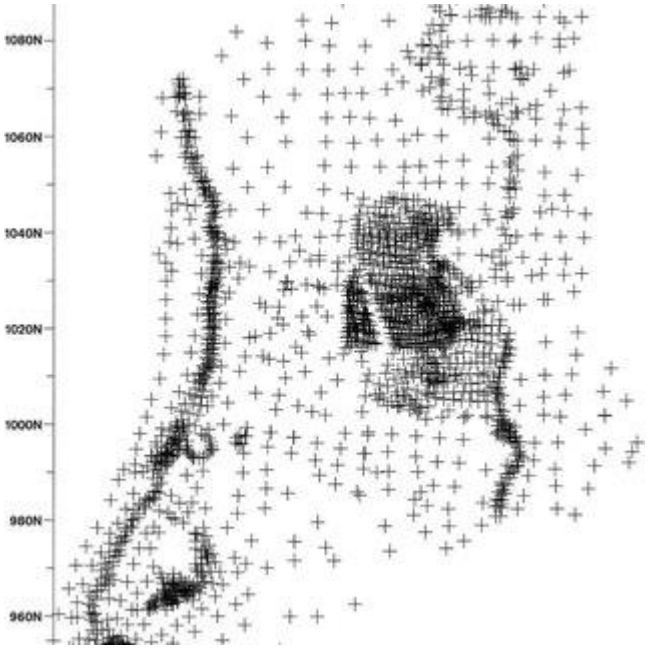


Figure 15 Reading points with TS equipment

It worth mentioning that in hilly and valley area where slopes changing rapidly we need to read more points meaning the distance between point should be shorten, but in contrary in plain land, for instance in a plain area where slope changes smoothly or no slope , we can take points each 10m but

in hilly area we will take it each 2 meter or some times less, there is many other privileges for using total station or new era survey instrument such as, taking description of each point instead of taking it manually in your booklet, and immediately specifying bench marks and references, in addition covering of wide area in a short time, some surveyors covers 50, 60 and even more donums each day, in case prepared well and not faced odd situation.

2. **Desk work and designing**

Nowadays technology has its interaction in everything in our lives so for sure it affected the designing stage not only road but every engineering projects, either in managing stage or constructing and industrial projects, while here we are focusing on infrastructure projects , roads and sewerage, we should mention Two biggest company providing engineering software supporting this purpose, Autodesk and Bentley, both are pioneer not only in our field but generally in all engineering kind of projects

- Autodesk products is AutoCAD Civil 3D
- Bentley product is Open Roads, and MicroStation

Both are very effective and very smart and dynamic software, while my experience is with AutoCAD Civil 3D so my study will cover it and use Civil3D from now on.

Here I will share the Software interface to clarify be familiar with it and give some brief accordingly.

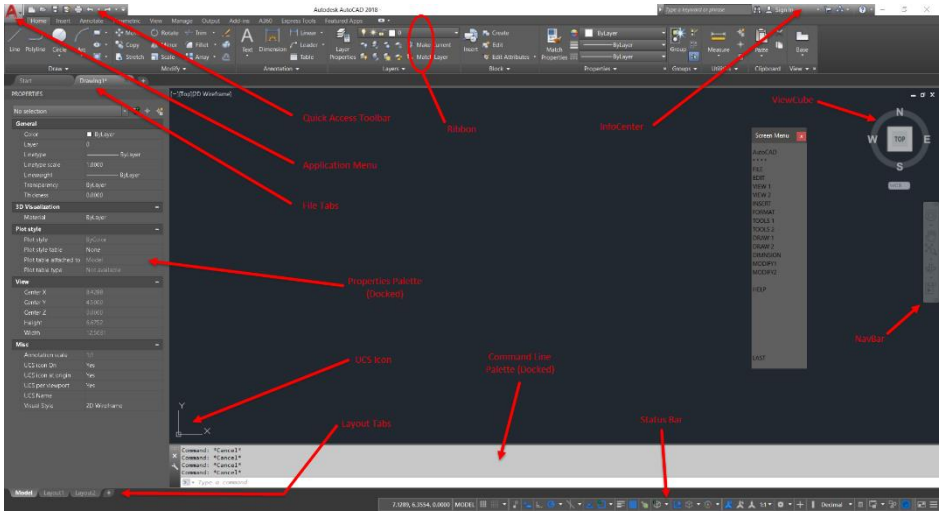


Figure 16 AutoCAD Civil3D interface

At this stage we have two main thing a skill in AutoCAD civil 3D and a file with containing all the surveyed points from the field.

We will import all the points to Civil 3D and the shape will be as following:

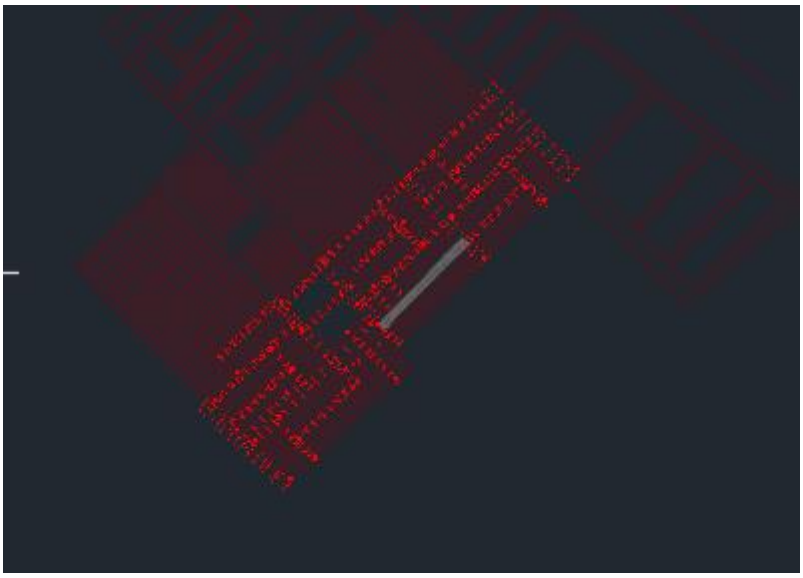


Figure 17 AutoCAD Civil 3D Importing points

After importing the points to Civil 3d from there we can add description of every and each points called (coding) in case we didn't during survey process, and here it ill be easier than doing it on the survey site, this coding will help in condition when for example we have house door coordinate, or manholes, electric poles, fire hydrant and many more.

From the survey points of the imported file, we can create a topography of the land in just a click very clearly and accurately, and the final topography will be as follow:

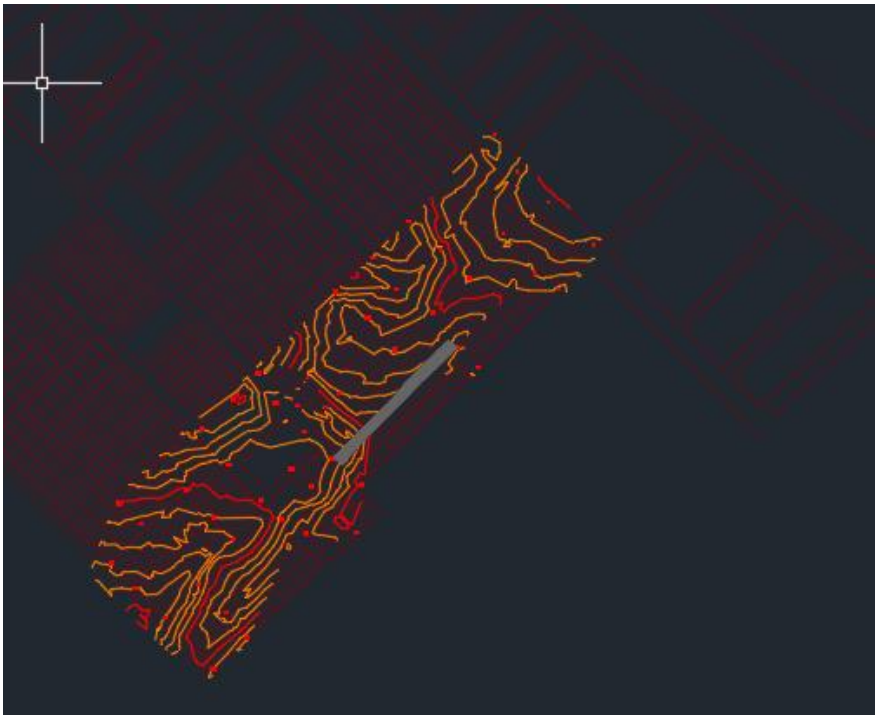


Figure 18 AutoCAD Civil 3D topography

From the first Impression on the topography immediately we will get an image of the overall city and how is the slope going on and in the later stage how sewerage and storm will pass, the topography will make a surface this surface will interpret all the points to 3D surface of the land or the area.

After reaching this progress the later steps with drawing poly line for designating alignment and profiles the design is like the previous and the old way design steps except all would be done and computerized with Civil 3D software.

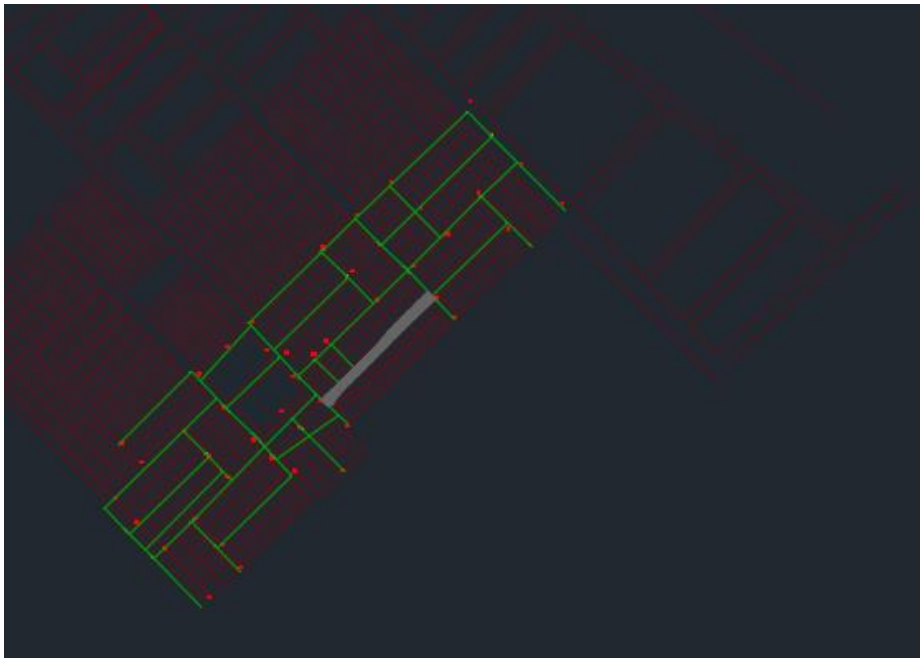


Figure 19 AutoCAD Civil 3D alignment

From the alignment we will create similar profile for the NG and the same way we will add final design level this one compared the old version is more revised because it covers all the slope, curvature, start and end point of the curve slopes and many other details which is very easy to be implemented on site.

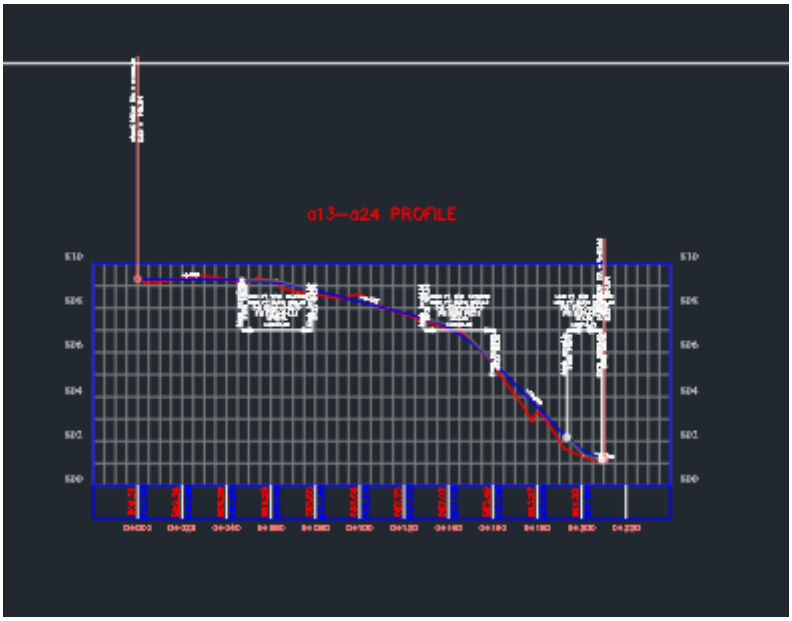
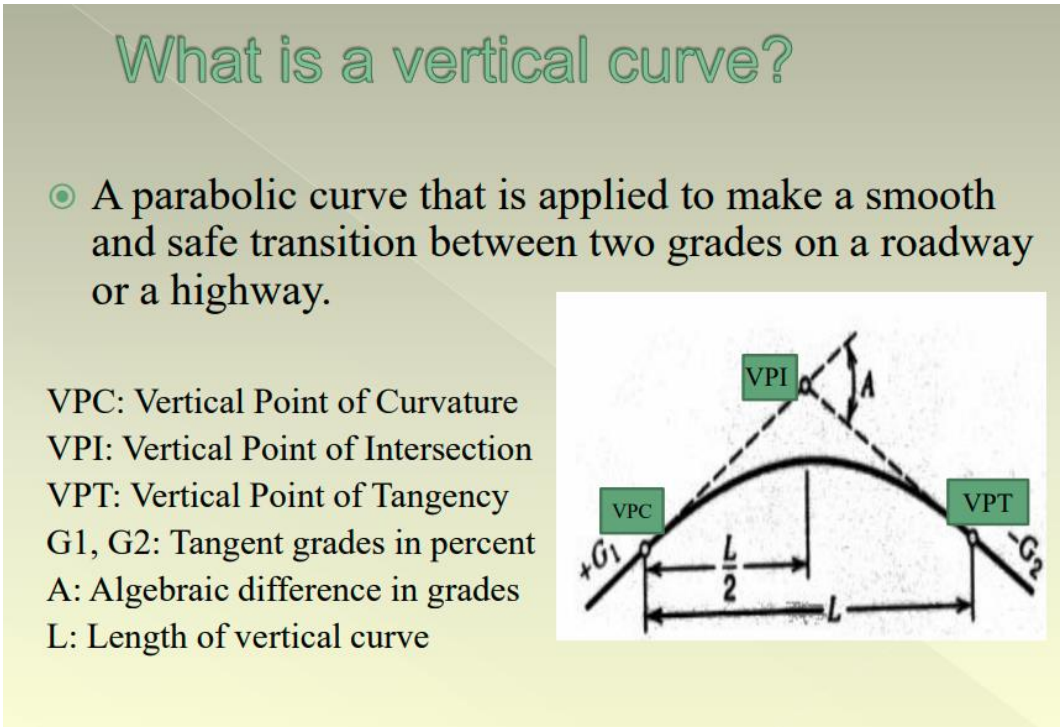


Figure 20 AutoCAD Civil 3D profile

As shown in the profile all the data needed for implementing the road are available starting from slopes and curvature information as bellow the crest and sag curvature data.



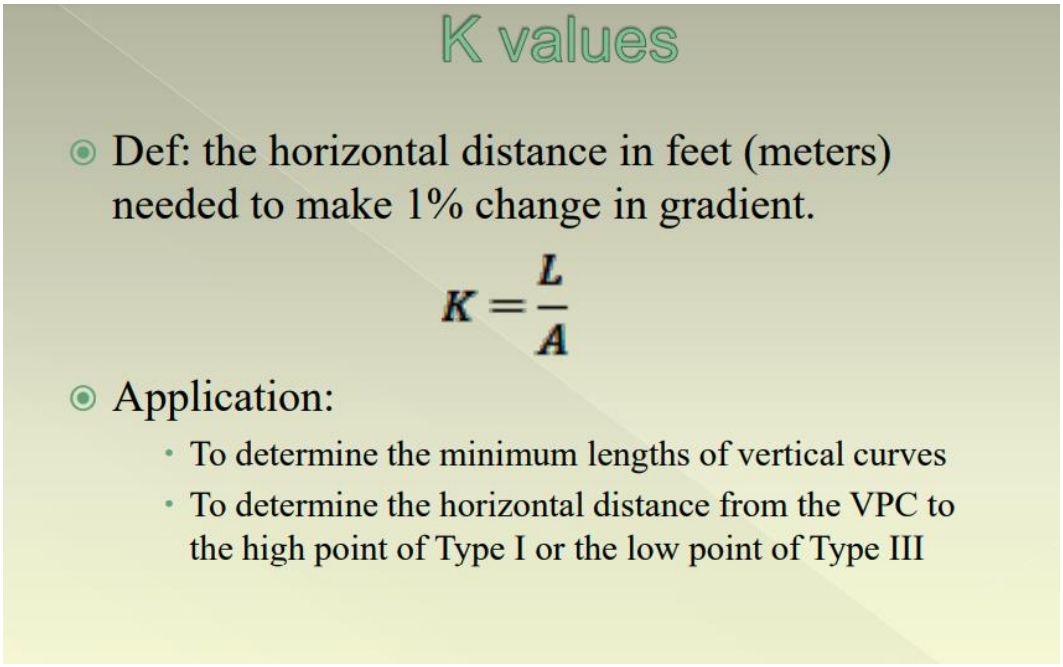
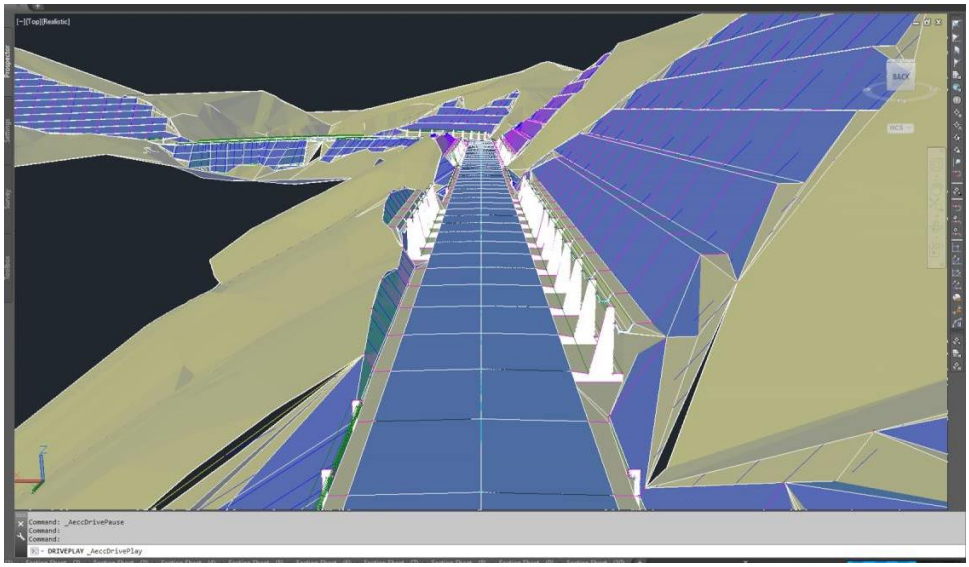


Figure 21,22 Vertical curvature of roads

The next stage will be creating cross sections of the roads and how is side slope then how excavation working is it fill or cut area and accounting those amounts for tendering and BoQ purposes.

To proceed with this, we will make the road design not only of the center but as long as the width of the road for making that, there is one thing called Corridoes serving these purposes. Corridor will be created from the same alignment and a typical cross section of the road, and this will be more useful in highway projects because it shows you all the embankment, sides, fills, cut, retaining walls and every other needed item in whatever station we need.



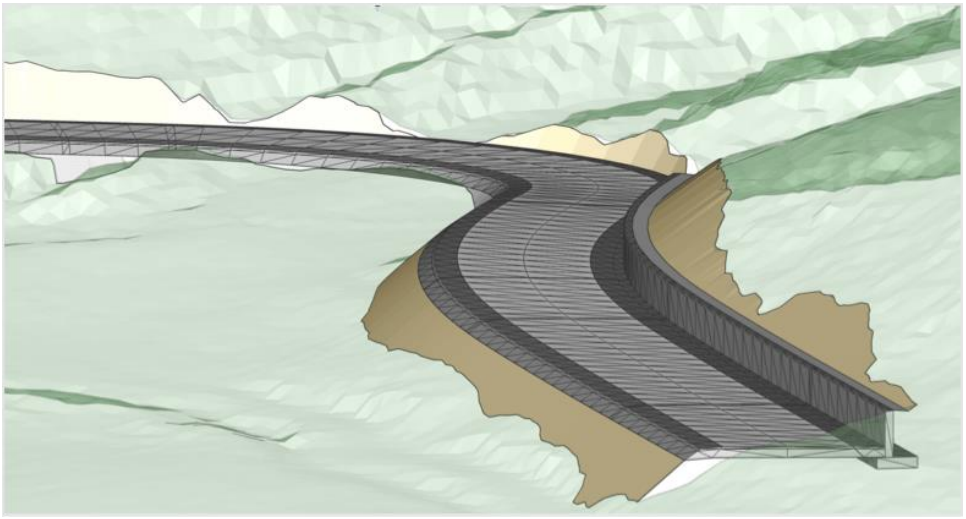


Figure 23 corridors in 3D

From these corridors we can build lot of cross section at each station we need, and the final 3D shape of the road, and almost estimating all the amount we need in the BoQ preparation stage.

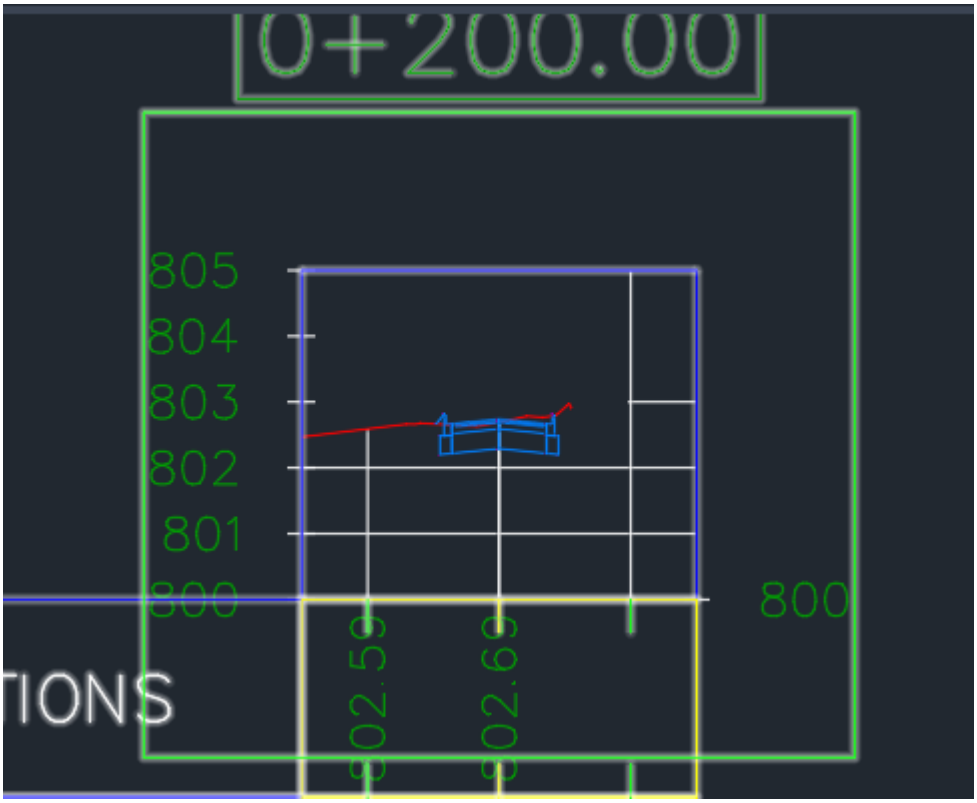


Figure 24 Cross-section at specific station

3. **Sewerage design:**

With the completion of road design, you're ready to move on to another major area of design: pipe design. One type of pipe design that you must address as a designer is the safe and efficient collection and conveyance of water that falls on a site during a rainstorm. This type of pipe design is part of a larger design process called stormwater management. Because the development of land often involves turning absorbent surfaces (soft grassy soil, trees, and forest floors) into impervious surfaces (pavement, concrete, and asphalt rooftops), rain that falls on a developed site will travel farther and much faster when compared to rain that fell on the site before it was developed. This water on the move can cause erosion or flooding, so it must be safely collected and placed in surface channels or underground pipes. The pipes and channels then carry the water to a safe place where it can be discharged without doing harm. (Classes)

There are two main items in sewerage or storm pipe system, structure (manholes and inlet) and pipes generally.

Create a Pipe Network by Layout, you'll create part of the storm system using the Pipe Network Creation Tools Open the drawing named Creating Pipe Networks by Layout. If you study the placement of inlets, you should notice that some of them have been placed at low points, to prevent the inlets at the low points from being overloaded, additional inlets have been placed between low points and high points to collect some of the runoff. On the Home tab of the ribbon, click Pipe Network ➢ Pipe Network Creation Tools in the Create Pipe Network dialog box, do the following: a. For Network Name, enter Storm1. b. For Network Parts List, select Storm Sewer. c. For Surface Name, select Road FG. d. For Alignment Name, Click OK.

This way draw the pipe line or its better the pipe system design in the plan, and easily those design can be moved to the existing profiles which we already made previously for road design, from there all the hydraulic aspect should be checked starting from slope, velocity, pipe diameter type of pipe all the other items, for each manhole you can add whatever data you need, manhole depth, top elevation, dimensions, name of manhole and pipe invert levels, and the final image of the profile will be as follow:

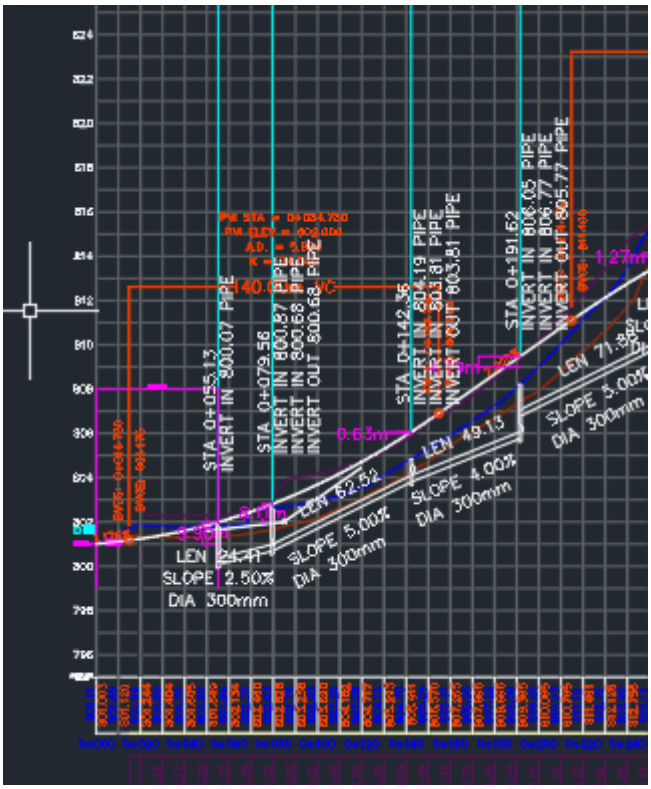


Figure 25 Sewerage design

Comparison and conclusion:

Here I am trying without exaggeration and realistically compare what we were doing previously for the purpose of road and storm design, and what we are doing right now, and where are simply the weakness and advantages of both eras.

As we split the stage of work to thresholds, we can do the same to discuss and show what a privilege do we have right now.

This study found the same tasks were completed 95% faster when using Civil 3D, a direct time savings of 43hours, 40 minutes through the course of the project. An increase in accuracy and precision were also seen in most tasks, reducing the potential for errors and rework. It is impossible to quantify possible rework amounts, but where typical errors could be avoided.

There were several tasks that the AutoCAD process was technically faster. In these cases, the Civil 3D process will, in the long-term, end up being more efficient due to the dynamic updating ability of the Civil 3D object data. Finally, there were also several tasks that were simply not realistic to perform using AutoCAD.


On site work and new survey equipment as time management aspect are more creative and critical because we will get the same result in a short ideal time, we might implement 5-10 days survey work with conventional equipment in only one day work and even shorter.


Regarding the accuracy of work because the tools are more accurate and developed it feeds back us with better and more precise data from the land. The reflector and installment of the GPS are more stable and reliable.


In case of using survey, drones there is a privilege of getting satellite image in addition to the survey date where easily can be checked with the existing milestones and landmarks on the maps.


In terms of logistically for sure less paperwork needed and majority of thee work will be data files, and less human resources, in the result will cost less and cost saving matter will be manifested and can be noticed easily.

Time management will be great aspect always in every project now and always, so in term of office works, less time will be needed for accomplish the projects.

More accurate data can be driven from the software such as Civil3D, and could be checked easily, for instance if we had a point accounted or added mistakenly into the topography or surface it shows immediately and can be corrected easily.

Type of the profiles and its relation to on site implementation is easier, at any time and in any place, we can order sections or profiles, estimations, and many other data from the designer in an ideal time, and its easy to cope up, this is true for as build time when we are in the face of collecting and registering these data to Governmental data bank.

Everything can be dynamic in the system in a meaning when we are changing some points or removing or adding to the surface this will automatically change the topography and any other related data to this change.

- For sewerage time element is correct as well, giving results faster.
- Type of the profiles with storm system added, give more details regarding all the existing structures, and can be checked and changed easily, specially there are other steps of checking pipes slopes and hydraulic aspect.
  Overall, we can say time, economy, human resources, and logistic resources will be saved in new era design steps.

- (https://www.jonasconstruction.com/blog/phases-of-construction-project-management/, n.d.)
- (https://www.smartsheet.com/construction-project-management-101, n.d.)
- (ICSM, n.d.)
- (Classes)