

ROAD SURVEY USING TOTAL STATION AND DESIGN OF FLEXIBLE PAVEMENT

**A Project Report Submitted in fulfilment of the requirements for
the award of the degree of Bachelor of Technology.**

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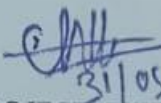


**DEPARTMENT OF CIVIL ENGINEERING
GANDHI INSTITUTE FOR TECHNOLOGY,
BHUBANESWAR
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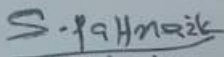


CERTIFICATE

This is here to certify that the project entitled “Road survey using total station and design of flexible pavement “has been submitted to the department of Civil Engineering, Gandhi Institute for Technology (GIFT) Autonomous College, Bhubaneswar, Odisha in fulfilment of requirements for the Bachelor of technology degree in Civil Engineering under Biju Patnaik University of Technology (BPUT), Rourkela, Odisha.


31/05/23
PROJECT GUIDE
EXTERNAL


31/5/23
PROJECT COORDINATOR


31/5/23
HOD(CIVIL)


31/5/23
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DECLARATION

I declare that this project report titled “**Road survey using Total station and design of flexible pavement**” submitted in partial fulfilment of the degree of B. tech in civil engineering is a record of original work carried out by us under the supervision of Asst, Prof. Chitrabhanu Sahoo, and his not forward the basis for the award of any other degree, in this or any other institutions or university. In keeping with the ethical practice in reporting scientific information, due acknowledgements have been made wherever the findings of other have been cited.

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ABSTRACT

In the current scenario the growth of a nation is totally depends upon the road infrastructure and connectivity of that nation. So, at the same time it's equally important to construct sustainable and environment friendly roads in the country. This study compares the applications of novel surveying technologies for road surface mapping by total Stations and design of flexible pavement by using IIT pave. This project is on GIFT college Gate to Khordha - Chandaka Road. This is the road that connect our college and it is around 300 m stretch. In particular, a Leica TCRP 1203 instruments was used for surveying. This study deals with issues of road surveying under light traffic condition, the safety of surveyors, work methodology, optimization of surveying time, traffic volume study during 8.00-9.00am and 3.30-4.30pm. The aspects of data processing, assessment, traffic analysis, flexible pavement design as per IRC:37-2018 are also handled. Possible reasons for detected discrepancies between different approaches are discussed in detail. The methods in question both allow the accurate determination of paving material volumes that should be milled off the upper layer of the road surface and the volume of the filling material required to achieve a smooth road surface. However, this study evaluates the use of conventional surveying methods such as total station surveying in road surface mapping and design of flexible pavement (code IRC: 37) as well as the material evaluation. Now-a-days, handling the waste from different industry is a challenge. So, this study also evaluates the sustainability of waste material to construct the flexible pavement inside the college campus. Software used IIT pave, AutoCAD, Staad Pro.

Keywords: Surveying, Flexible pavement design, characterization of material, IRC 37, IIT pave, AutoCAD, Staad Pro

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INTRODUCTION:

The purpose of this report is to present the design of a flexible pavement for a bike parking based on a survey and analysis conducted in a particular area. The report outlines the finding of the survey, analysis, and design process, including the methodology, materials and standards used. The final design is based on the results of the survey and analysis, taking into consideration the anticipated traffic volumes, environmental condition, and local regulations.

- The Total station is designed for measuring of slant distances, horizontal and vertical angles and elevations in topographic and geodetic works, tachometric surveys, as well as for solution of application geodetic tasks. The measurement results can be recorded into the internal memory and transferred to a personal computer interface.
- The basic properties are unsurpassed range, speed, and accuracy of measurements. Total stations are developed in view of the maximal convenience of work of the user. High-efficiency electronic tachometers are intended for the decision It has the broad audience for sole of industrial problems.
- Angles and distances are measured from the total station to points under survey, and the coordinates (X, Y, and Z or northing, easting, and elevation) of surveyed points relative to the total station position are calculated using trigonometry and triangulation.
- Data can be downloaded from the total station to a computer and application software used to compute results and generate a map of the surveyed area.
- A total station is an electronic/optical instrument used in modern surveying. It is also used by archaeologists to record excavations as well as by police, crime scene investigators, private accident Reconstructionist and insurance companies to take measurements of

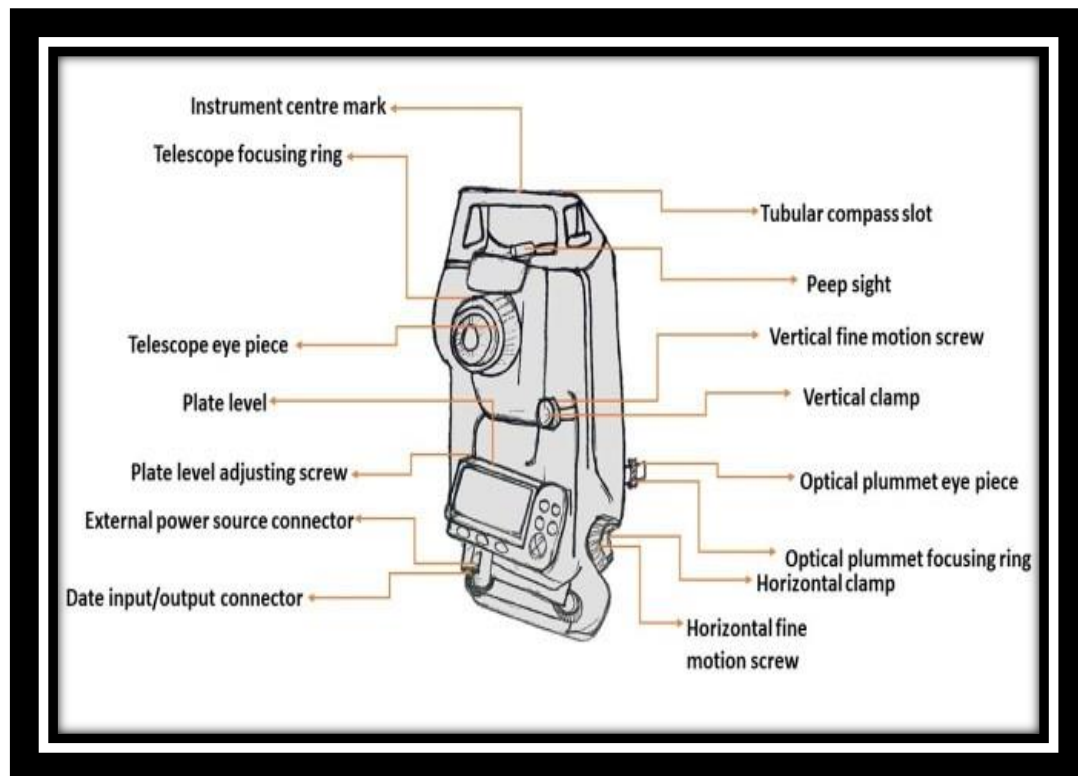
scenes. The total station is an electronic theodolite (transit) integrated with an electronic distance meter (EDM), plus internal data storage and/or external data collector.

- The purpose of any survey is to prepare maps, control points formed a basic requirement for the preparation of these maps.
- There are several numbers of methods like traverse, triangulation etc., to provide these control points.
- Whatever the method the provision of control points, includes the measurement of two entities (Distance and Angle).
- Again, distance can be measured by using various instruments like chain, tape.
- Linear Tap.
- Gunter's chain (20m and 30m).
- Steel band (20m and 30m).
- Inver tap.
- Hunter Short Base (80m).
- Electronic Distance Measurement Instruments, Total station, and GPS.
- Angle can be measured by using a THEODOLITE.
- Once distance and angular measurement is over computation is performed to provide the control points. A combination of all the three results in a powerful instrument called **TOTAL STATION**. Hence, the **TOTAL STATION** is an instrument which consists of the following:

- i) Distance measuring instrument (EDM).
- ii) An angle measuring instrument (Theodolite).
- iii) A simple microprocessor.

INSTRUMENTATION

- It consists of an EDM, Theodolite, Microprocessor combined into one. It also has a memory card to store the data. It also consists of battery socket which houses the battery. A fully charged battery works for about 3 to 5 hrs continuously.



(Fig.1 Parts of total station)

ACCURACY OF A TOTAL STATION

Accuracy depending upon the instrument and varies from instrument to instrument

- 1.The angular accuracy varies from 1" to 20 ".
- 2.Distance accuracy depends upon two factors.

Instrumental error which ranges from

+ / - 10mm to + / - 2mm.

b) Error due to the length of measurement.

It can be from $+ / - 10\text{mm}$ to $+ / - 2\text{mm}$ per kilometre.

1 prism, 2.5–2.7 km² prisms

5-7 km³ prisms

10-12 km NIKON One second $+ / - 2\text{mm/km}$ or 2ppm Triple the number of prisms double the distance. LEICA One second SOKKIA One second.

ACCURACY AND PRECISION

- Precision is the reproducibility of the measurement.
- Accuracy is how close the measured position is to the actual location

Measurement of distance is accomplished with a modulated microwave or infrared carrier signal, generated by a small solid-state emitter within the instrument's optical path, and reflected by a prism reflector or the object under survey. The modulation pattern in the returning signal is read and interpreted by the onboard computer in the total station. The distance is determined by emitting and receiving multiple frequencies, and determining the integer number of wavelengths to the target for each frequency. Most total stations use purpose-built glass Porro prism reflectors for the EDM signal, and can measure distances to a few kilometers. Reflector fewer total stations can measure distances to any object that is reasonably light in colour, to a few hundred meters.

TOTAL STATION CAN BE USED

- When two points are given.
- When only one co-ordinate is given. In this case the coordinate of the back station is determined by any suitable method.
- When no co-ordinates were given in which case arbitrary system of coordinates can be used.

- These devices, also called electronic Tachometers, can automatically measure horizontal and vertical angles as slope distance from a single set up. From these data they can instantaneously compute horizontal and vertical distance components, elevations, and coordinates, and display the results on LCD. They can also store the data, either on board or in external data collectors. If the coordinates of the occupied station and a reference azimuth are input to the system, the coordinates of the sighted point are immediately obtained. This information can be directly stored in an automatic data collector, thereby eliminating manual recording. These instruments are of tremendous value in all types of surveying. Total Stations offer many advantages for almost all types of surveying. They are used for topographic, Hydrographic, cadastral, project and construction surveys.

ACCESSORIES FOR TOTAL STATION

- With approximately more than 40 different models are available to choose, they are currently the dominant instrument in surveying.
- The EDM instrument component installed in a Total Station is relatively small but still has distance ranges adequate for most work. Lengths up to about 2 km can be measured with a single prism, and up to about 6 to 7 km with triple prism.
- The angle resolution of available Total Stations varies from as low as a half-second for precise instruments suitable for control surveys, up to 20" for instruments made specifically for construction stakeout.



(fig.2 Accessories of TS)

FUNCTION PERFORMED BY T.S

Total Stations, with their microprocessors, can perform a variety of functions and computations, depending on how they are programmed. The capabilities vary with different instruments, but some standard computations include:

- Averaging multiple angle and distance measurements.
- Correcting electronically measured distances from prism constant, atmospheric pressure, and temperature.
- Making curvature and refraction corrections to elevations determine by trigonometric levelling.
- Reducing slope distances to their horizontal and vertical components.
- Calculating point elevations from the vertical distance components (supplemented with keyboard input of instrument and reflector heights).

- Computing coordinates of survey points from horizontal angle and horizontal distance.
- Averages multiple angle measurements.
- Averages multiple distance measurements.
- Computes horizontal and vertical distances.
- Corrections for temp, pressure, and humidity.
- Computes inverses, polars, resections.
- Computes X, Y and Z coordinates.

Because the Total Station contains delicate electronic components they are not as rugged as ordinary Theodolite. They must be packed and transported carefully, handled gently and carefully removed from their cases.

The setting of Total Station over the station mark is similar to an ordinary Theodolite. This includes

- Centring
- Levelling
- Removal of parallax

Total Stations are controlled with entries made either through their built-in keyboards or through the keyboards of hand-held data collectors. Details for operating each individual total station vary somewhat and therefore are not described here.

The accuracy achieved with total station is mainly depends on operator procedure of Careful centering and levelling of the instrument

- Accurate pointing at targets.
- Taking averages of multiple angle measurements made in both direct and reverse positions

Peripheral equipment that can affect accuracy includes

- Tribrachs
- Optical plummets
- Prism and

- Prism poles

Tribrachs must provide a snug fit without slippage. Optical plummets that are out of adjustment cause instruments to be set up erroneously over the measurement point. The prism poles should be perfectly vertical and prism should be well fitted on that. Prisms should be checked frequently to determine their constants.

APPLICATIONS OF T.S

There are many other facilities available, the total station can be used for the following purposes.

- Detail survey i.e., data collection.
- Control Survey (Traverse).
- Height measurement (Remove elevation measurement- REM).
- Fixing of missing pillars (or) Setting out (or) Stake out.
- Resection.
- Area calculations, etc.
- Remote distance measurement (RDM) or Missing line measurement (MLM).

DATA COLLECTION OPTION

Measurements can be stored “on board” with all the total stations. The two options that are available are

- Data can be stored directly in the memory of the microcomputer, and later downloaded to an external storage device via a RS – 232 connections.

- The second option is the removable memory card. When one card is full, it can be removed and another card can be quickly installed.

DETAIL SURVEY

Given two points whose coordinates are known, a total station can be used to get the coordinates of various other points based upon those two co-ordinates. Care should be taken that the new points survey is carefully coded. The Map of the area can be obtained after downloading and processing.

CONTROL SURVEY / TRAVERSE

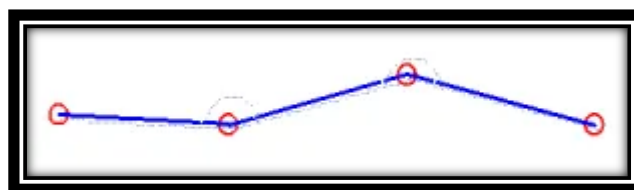
It is similar to any type of EDM Traverse.

Definition of Traverse: –

Traverse is the method of control survey in providing horizontal and vertical controls along a pre-defined route by means of establishing a series of connected lines joining the traverse stations.

TRAVERSE

- In traverse a number of connected survey lines form a framework of survey.
- The direction and length of survey lines are measured with the help of an angular measuring device (Theodolite) and distance measuring device (Tape, chain, EDM, GPS etc.).



(fig.3 Traversing)

CLASSIFICATION OF TRAVERSE (Based on accuracy):

- Based on accuracy
- Primary traverse: accuracy 1:50,000 (Instrument: T3 and invar wire)
- Secondary traverse: accuracy 1:20,000 (Instrument: T3 and EDM)
- Tertiary traverse: accuracy 1:1000 (Instrument: T2 and Chain)
1:2000 (Instrument: T2 and Steel Band)
- Based on Instrument used
- Chain traverse
- EDM traverse
- Plane-table traverse

CLASSIFICATION OF TRAVERSE (Based on instrument used):

- **Open traverse:** Starts from a known control point and ends at unknown point.
- **Closed traverse:** Starts and ends at known control points.
- **Closed circuit traverse:** Starts from and ends at known control points.

APPLICATION OF TRAVERSE

- Providing control points for large scale surveys.
- Boundary surveys
- Fixing route of a river, road, canal accurately.
- Project surveys.
- Alignment surveys and many more.
- True North i.e., Meridian line
- Grid North line
- Magnetic North line
- Any arbitrary reference lines.

BACKGROUND OF THE STUDY:

The research deals with evaluation and comparison of precision, accuracy, and time expenditure of three surveying methods. These methods are total station (TS), Global positioning system (GPS), and terrestrial laser scanner (TLS). Surveying has been an essential element in the development of the human environment for so many centuries. It is an imperative requirement in the planning and execution of nearly every form of construction. Surveying was essential at the dawn of history, and some of the most significant scientific discoveries could never have been implemented, were it not for the contribution of surveying. Its principal modern uses are in the fields of transportation, construction building, apportionment of land, and detail mapping¹. In surveying, specifically in the area of engineering projects, more sophisticated instruments are employed (total station, laser scanner and GPS) to improve the efficiency and accuracy. Individual surveying techniques has been commonly used in the history of surveying area to collect data from field measurements for various applications with different accuracy capabilities and requirements. The significant development of surveying techniques enabled surveying

professionals to evaluate precision and accuracy of different surveying techniques. As a result of this evaluation, many advantages have been gained; basically, such as improving the efficiency and accuracy of the results. The accuracy of surveying measurements can be improved almost indefinitely with increased cost (time, effort and money). Today, the role of surveying got much attention to be used in many applications with better accuracy. The term accuracy is common in many applications to express the quality of observations, measurements or/and calculations. The required accuracy depends on the needed deliverable output. Applications such as general navigation tasks on the sea, research in oceanography, position and velocity in small scale geophysical exploration are required low accuracy, applications such as hydrography, calibration of transponder system, precise navigation and seismic survey, precise navigation in coastal waters etc. are grouped as medium accuracy requirements and applications which require high accuracy are; precise hydrographic surveying, support of coastal engineering marine, geodynamics, precise continuous height control, engineering construction projects (Sjoberg, 2012). Accuracy and precision for those in the surveying profession (as well as other technical and scientific fields) are defined in different way. Accuracy refers to how closely a measurement or observation comes to measure a true or established value, since measurements and observations are always subject to errors. Precision refers to how closely repeated measurements or observations come to duplicate the measured or observed values. Accuracy of surveying techniques using instruments such as GPS, TS and TLS are dependent on a number of parameters that limit their measurement quality. For instance: multipath, the inherent satellite signal accuracy, signal transmission delay, receiver hardware and software limitations, satellite signal obstruction are some of the problems associated with GPS measurement. On the other hand, limitations stemming from total station are; computed coordinates are in local or target coordinate system, the reference surface for measuring height is geoid.

Because of earth's curvature, the accuracy of TS measurement can also be affected by distance limit (the accuracy will decrease when increasing the distance). Finally, accuracy of laser scanner depends on the angle of sight and distance from the object to be scanned i.e., scanning perpendicular to the object is more accurate than slightly inclined scanning. Even if laser scanner can capture thousands of points per second, all of these points cannot be handled easily to manipulate and store. Therefore, each method has its own advantages and disadvantages. In addition to the above differences, the methods have also different time consumption to do the required tasks. Thus, the scope of the research is to evaluate and compare accuracy, precision, and time expenditure of the above three methods.

PROBLEM STATEMENT:

Surveying is the technique and science of accurately determining three-dimensional position of points and the distances and angles between them. Various surveying methods (GPS, laser scanner, total station, etc.) are in use. In this research only these instruments have been used. The latest geodetic GPS receivers are improving the accuracy of positioning information, but in critical locations such as urban areas, the satellite availability is difficult due to the signal blocking problem, multipath etc. which degrade the required accuracy. 3D laser scanners generate up to thousands of points per second, however, handling and manipulating the huge amount of point data is a major problem. To avoid these problems, it is very important to reduce the amount of acquired point data. As a result of this reduction of data, accuracy of the final result will be altered. Total station can measure a single point coordinate precisely, but the computed coordinates are in local or target coordinate system, which needs datum transformation. The accuracy is affected with angle and distance of sight, weather condition, etc. Considering those limitations, the research will evaluate

and compare accuracy, precision and time expenditure of these three surveying methods (total station, GPS and laser scanner).

OBJECTIVES OF THE RESEARCH:

The general objective of this research is intended to evaluate and compare the accuracy, precision and cost (time expenditure) of three methods, i.e., GPS, total station and laser scanning. Specifically, the research intends to:

- Determine and evaluate precision of the reference network which can be served as a reference value for comparison with RTK and TLS
- Determine and evaluate accuracy and precision of GPS RTK and TLS methods Determine the cost (time expenditure) of the three methods
- Compare results of the methods based on RMS and standard deviation analysis
- Forward possible recommendations that can improve the precision and accuracy of the three measurement methods.

OBJECTIVES AND REQUIREMENTS OF THE PAVEMENT

- The soft piece of equipment should be stable and non-yielding, to allow the heavy wheel load of the road traffic to move with least possible rolling resistance.
- The road should be even along the longitudinal profile to enable the first vehicles to move safely and comfortably at the design speed.

- A pavement layer is considered more effective or superior, if it is able to distribute the wheel load stress through a larger area per unit depth of the layer.
- Elastic deformation of the pavement should be within the permissible limits so that the pavement can sustain a large number of repeated load applications during the design life.
- It is always desirable to construct the pavement well above the maximum level of the groundwater to keep the subgrade relatively dry even during monsoons. At high moisture contents the soil becomes weaker and soft and starts yielding under heavy wheel loads, thus increasing the tractive resistance.

TYPES OF PAVEMENTS

Based on the structural behaviour, pavements are generally classified into the following three categories:

1. Flexible pavement
2. Rigid pavement
3. Semi-rigid pavement

FLEXIBLE PAVEMENT

Flexible pavements are those which are flexible in their structural action under the loads. Some important features of these pavements are.

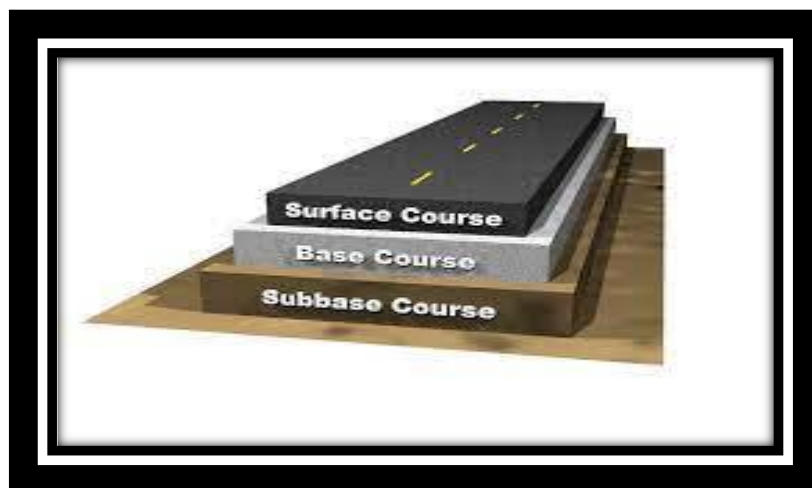
- It has no flexural strength.
- It reflects the deformation of lower layer.
- It will transmit the vertical compressive stress to bottom layers by grain-to-grain transfer,
- The lower layer have to take up only lesser magnitudes of stress and there is no direct wearing action due to traffic loads, therefore inferior materials with low cost can be used in the lower layers.

Flexible pavements consist of the following components:

- a) Soil sub grade
- b) Sub base course
- c) Base course
- d) Surface course

Bituminous concrete, granular materials with or without bituminous binder, WBM , soil aggregate mixes etc., are common examples of flexible pavements.

Flexible pavements are commonly designed using empirical chart or equations. There are also semi empirical and theoretical methods for the design of flexible pavements.



(Fig.4 Cross-Section of flexible pavement)

RIGID PAVEMENT

Rigid pavements are those which possess noteworthy flexural rigidity.

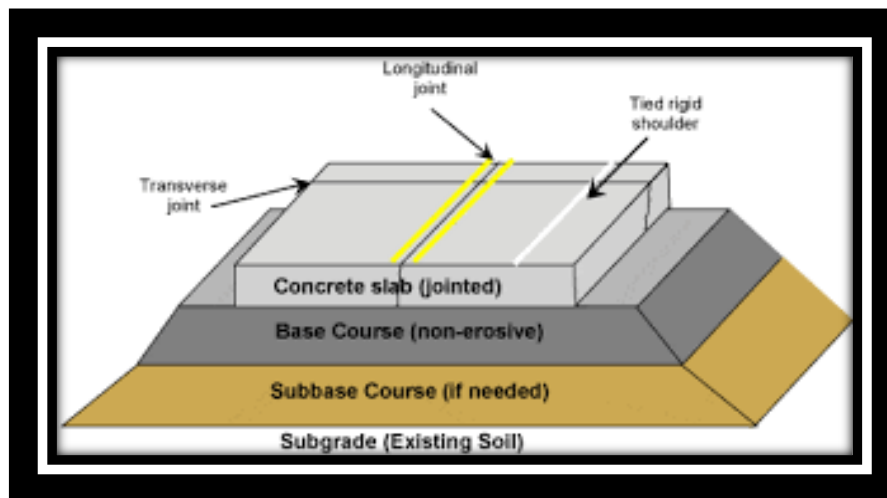
- It possesses flexural strength.
- Load transfer is by the way of slab action and it distributes the wheel load to a wider area below
- Flexural stresses will be developed due to wheel load temperature changes

- Tensile stresses will be developed due to bending action of the slab under the wheel load
- It does not deform to the shape of lower layer, but it bridges the minor variations of the lower layer.

Rigid pavement consists of the following components:

- a) Cement Concrete slab
- b) Base course
- c) Soil sub grade

Rigid pavements are made of Portland cement concrete either plain, reinforced or prestressed. The plain cement concrete is expected to take up about 40kg/cm² flexural stress. These are designed using elastic theory, assuming the pavement as an elastic plate resting over an elastic plate resting over an elastic or viscous foundation.



(fig.5 Cross-section of Rigid pavement)

SEMI-RIGID PAVEMENT

Wheel bonded materials like pozzolanic concrete, lean concrete or soil cement are used, then the pavement layer has considerably high flexural strength than the common flexible pavement is called a semi-rigid pavement.

These materials have low resistance to impact and abrasion and are therefore used with flexible pavement surface course.

FUNCTION OF PAVEMENT COMPONENTS

SOIL SUBGRADE

- The pavement load is ultimately taken by soil sub grade and hence in no case it should be over stressed and top 50cm layer of soil sub grade should be well compacted at O.M.C.
- Common strength tests used for evaluation of soil sub grade are:
 - a) California bearing ratio test
 - b) California resistance value test
 - c) Triaxial compression test
 - d) Plate bearing test

SUB BASE AND BASE COURSES:

- These are broken stone aggregates. It is desirable to use smaller size graded aggregates at sub base course instead of boulder stone.
- Base and sub base course are used under flexible pavement primarily to improve load supporting capacity by distribution of load through a finite thickness.
- Base courses are used under rigid pavements for:
 - a) Preventing pumping
 - b) Protecting the sub grade against frost action

WEARING COURSE

- Purpose of this course is to give smooth riding surface. It resists pressure exerted by tyres and takes up wear and tear due to traffic. It also offers water tightness.
- The stability of wearing course is estimated by Marshall stability test where in optimum percent of bituminous material is worked out based on stability density, voids in mineral aggregate (V M A) and voids filled

with bitumen (V F B). Plate Bearing test are also sometimes made use for elevating the wearing course and the pavement as a whole.

FACTORS TO BE CONSIDERED IN THE DESIGN OF PAVEMENTS:

Pavements design consists of two parts:

- Mix design of material to be used in each pavement component layer
- Thickness design of the pavement and the component layer

The various factors to be considered for the design of pavements are:

- Design wheel load
- Sub grade soil
- Climatic factors
- Pavement component material
- Environment factors
- Special factors in the design of different types of pavements

DESIGN WHEEL LOAD:

Following are the important wheel load factors:

(A) MAXIMUM WHEEL LOAD

Maximum legal axle load as specified by IRC is 8170kg with a maximum equivalent single wheel load of 4085kg. Total load influences the equality of surface course.

The vertical stress computation under a circular load is based on Boussineq's theory.

(B) CONTACT PRESSURE

- Tyres pressure of high magnitudes demand high quality of materials in upper layers in pavements, however the total depth of pavement is not governed by tyre pressure.

- Generally, wheel load is assumed to be distributed in circular area but it is seen that contact area in many cases is elliptical.
- Commonly used terms with reference of the tyre pressure are:
 - a) Tyre pressure
 - b) Inflation pressure
 - c) Contact pressure
- Tyre pressure and inflation pressure mean exactly are the same. The contact pressure is found more than tyre pressure when tyre pressure is less than 7 kg/cm² and its vice-versa when the tyre pressure exceeds 7kg/cm².

Rigidity factor = (contact pressure)

R.F =1, For tyre pressure is 7 kg/cm²

R.F <1, for tyre pressure > 7kg/cm²

R.F >1, For tyre pressure <7 kg/cm²

(C) EQUIVALENT SINGLE WHEEL LOAD(ESWL):

- The effect on the pavement through a dual load assembly is not equal to two times the load on any one wheel. The pressure at a depth below the pavement surface is between the single load and two times load carried by any one wheel.

(D) REPETITION OF LOAD:

- If the pavement structure fails with N; number of repetition and P; kg load and similarly if N₂ number of repetitions of p₂ kg load can also cause failure of the same pavement structure then P₁N₁ and P₂N₂ are equivalent.
- If the thickness required for 10 to the power 6 repetition is “t”, then the pavement thickness required for failure at one repetition is t/4

(E) ELASTIC MODULII:

- Elastic moduli of different pavement material can be evaluated. Mainly plate bearing test is employed for this purpose.
- If Δ is the maximum vertical deflection of the flexible pavement, then

$$\Delta = 1.5pa / E_s$$
- If rigid circular plate is used instead of flexible plate, then;

$$\Delta = 1.8 pa / E_s$$

Where, a = radius of plate

P = pressure at deflection

E_s = young's modulus of pavement material

SOIL SUB GRADE:

- The properties of soil sub grade are important in deciding the thickness of the pavement to protect it from traffic loads. The variations in stability and volume of sub grade soil with moisture changes are to be studied as these properties are dependent on the soil characteristics. Apart from the design, the pavement performance to great extent depends on the sub grade soil properties and drainage.
- The desirable properties of soil as pavement materials are:
 1. Stability
 2. Incompressibility
 3. Permanency of strength
 4. Minimum changes in volume and stability under adverse condition of weather and ground water
 5. Good drainage
 6. Ease of compaction

CLIMATIC FACTORS:

The climatic variation causes the following major effects:

1. Variation in moisture content,
2. Frost action,
3. Variation in temperature

VARIATION IN MOISTURE CONTENT:

The stability of most of the sub grade soils are decreased under adverse moisture conditions. Presence of soil fraction with high plasticity will result in variations in volume with variation in water content. As the moisture content of the sub grade below the centre is often different from that of the pavement edges, there can be differential rise or fall of the pavement edges with respect to the centre, due to swelling and shrinkage of the soil sub grade. These effects are likely to cause considerable damage to the pavement and also will be progressive and cumulative.

FROST ACTION:

Frost action refers to the adverse effect due to frost heave. Due to continuous supply of water capillary action at sub-freezing temperature leads to the formation of frost heave. The non uniform heaving leads to undulations.

Factors on which frost actions depends are:

1. Frost susceptible soil,
2. Depressed temperature below the soil,
3. Supply of water,
4. Cover

To reduce the damage due to frost action, proper surface and sub surface drainage system should be provided. Capillary cuts offs can also be provided to reduce the adverse frost action by soil stabilization.

VARIATION IN TEMPERATURE:

Wide variation in temperature due to climatic changes may cause damaging effects in some pavements. Temperature stresses of high magnitude can be induced in cement concrete pavements due to daily variations in temperature and consequent warping of the pavement. Bituminous pavement becomes soft in hot weather and brittle in very cold weather.

DESIGN OF FLEXIBLE PAVEMENT:

Various approaches for flexible pavement design may be classified into three broad groups:

(a) Empirical method:

- These are based on physical properties and strength parameters of soil sub grade.
- The group index method, CBR method, Stabilimeter method and Mc load method etc...., are empirical methods.

(b) Semi empirical methods or semi theoretical methods:

These methods are based on stress strain function and experience.

(c) Theoretical methods:

These are based on mathematical computations. For example, Burmister method is based on elastic two-layer theory.

GROUP INDEX METHOD:

D.J Steel suggested the thickness requirements with the Highway Research Board method based on the group index values in 1945. Group index value is an arbitrary index assigned to the soil types in numerical equations based on the percent fines, liquid limit and plasticity index. GI values of soil vary in the range of 0 to 2. The higher the GI value, weaker is the soil sub grade and for a

constant value of traffic volume, the greater would be the thickness requirement of the pavement.

The traffic volume in this method is divided into three groups:

Traffic volume (commercial vehicles)	No. of vehicles / day
Light	Less than 50
Medium	50 to 300
Heavy	Over 300

DESIGN STEPS:

Initially, the group index value is calculated for the soil sub grade based on the following formula:

$$GI = 0.2a + 0.005ac + 0.01bd$$

Where,

a = percentage of material passing through IS 200 (0.075mm) sieve, is more than 35 and less than 75 (0 to 40)

b = percentage of material passing through IS 200 (0.075mm) sieve, is more than 15 and less than 55 (0 to 40)

c = liquid limit more than 40 and less than (0 to 20)

d = plasticity index more than 10 and less than 30 (0 to 20)

DETERMINATION OF PERCENTAGE FINER THROUGH IS:200 SIEVE:

- Take 500 gms of the sub grade soil sample.
- Sieve it through IS: 200 sieves, while sieving through each sieve, the sieve should be agitated such that the sample roll in regular motion on the sieve.

- The mass of material retained on the sieve is determined and the value of percentage finer is determined using the formula.

Percentage finer = [(mass of soil passed) / (total mass of soil taken)] *100

DETERMINATION OF LIQUID LIMIT:

- The liquid limit of a soil is the water content at which the soil behaves practically like a liquid, but has smaller shear strength. It flows to close the groove in just 25 blows in Casagrande's liquid limit device. Take 150 gm of air-dried soil sample passing through 425 μ IS sieve.
- Mix the sample thoroughly with distilled water in evaporating dish or glass plate to form a uniform paste. Mixing should be continued for about 15 to 30 minutes till a uniform mix is obtained.
- Place the sample in the cup of the device by a spatula and level it to have a minimum depth of soil as 1cm at the point of the maximum thickness. The excess soil, if any, should be transferred to the evaporating dish.
- Cut a groove in the sample in the cup by using the appropriate tool. Draw the grooving tool through the paste in the cup along symmetric axis, along the diameter through the centre line of the cup. Hold the tool perpendicular to the cup.
- Give blows mechanically until the two halves of the soil specimen come in contact at the bottom of the groove along a distance of 12mm due to flow and not by sliding.
- Collect the representative sample and place the specimen in air tight container for water content determination and determine the water content.

DETERMINATION OF PLASTIC AND THUS, PLASTICITY INDEX:

- The plastic limit of the soil is the water content of the soil at which it ceases to be plastic. It begins to crumble when rolled into a thread of 3mm diameter.
- Take about 30gm of air-dried soil from a thoroughly mixed sample of soil passing 425 μ sieve.
- Mix the soil with distilled water in an evaporation dish or a glass plate to make it plastic enough to shape into a small bob.
- Leave the plastic soil mass for some time for maturing. Take about 8gms of plastic soil, roll it with fingers on the glass plate. The rate of rolling should be 80 to 90 strokes per minute to form a thread of 3mm diameter, counting one stroke when the hand moves forward and backward to the starting point.
- Repeat the process of alternate kneading and rolling until the thread crumbles, and the soil can no longer be rolled into thread.
- Collect the pieces of the crumbled soil thread in a moisture container and determine the moisture content.
- Then, obtain the plasticity index of the given soil sample using the formula:

$$\text{PLASTICITY INDEX} = \text{LIQUID LIMIT} - \text{PLASTIC LIMIT}$$

Based on the group index value, and the assumed traffic volume, the combined thickness of surface, base and sub base courses may be obtained from the design charts. Also, the thickness of surface and base course may be obtained from the charts.

CALIFORNIA BEARING RATIO METHOD:

- In 1928, California divisions of highways in USA developed CBR method for pavement design. The majority of curves developed later are based on the original curves developed by O.J. Porter. At the beginning of second world war, the corps engineer of USA made a survey of the existing method of pavement design and adopted CBR method for designing military airport pavements. One of the chief advantages of CBR method is simplicity of the test procedure.
- Most of the road pavements designed in CBR method on the CBR value of subgrade soil determined by conducting CBR test in the laboratory on the sub grade soil disturbed or remoulded depending on whether an existing sub grade is utilized for the pavement without improvement or a new sub grade is to be constructed with proper control over its properties, especially compaction characteristics.
- CBR value is defined as the ratio of load required to cause a specified penetration, say 2.5mm or 5mm of a standard plunger into the sample to the load required to produce the same penetration of same plunger into standard stone aggregate sample, expressed as a percentage.
- CBR value varies from 0 to 100%. More CBR indicates the stronger soil. If density is less, CBR is less. The CBR is expressed as percentage of penetration resistance of a given pavement material to that of a standard value of penetration resistance obtained for a crusher stone aggregate available in California.
- The thickness of the pavement is then obtained from the CBR value using the charts provided.

DESIGN OF PAVEMENT USING CBR METHOD: IRC

- CBR test should be performed on remoulded soils in laboratory, in-situ tests are not recommended for design purpose.
- The soil should be compacted at OMC to proctor density.
- Test samples should be soaked in water for 4 days period before testing. However, in dry zone (<50cm rainfall) it is not necessary to soak.
- At least three samples should be tested on each type of soil at the same density and moisture content. If variation is more than permissible value, an average of six samples should be considered.

Permissible variations	CBR (%)
3%	Upto 10%
5%	10 to 30%
10%	30 to 60%

- The top 50cm of sub grade should be compacted at least up to 95 to 100% of proctor density.
- Following formula may be used in case estimating future heavy vehicles in view of growth rate for design:

$$A = P(1+r)^{n+10}$$

$$A = P$$

A = no. of heavy vehicles/ day for design (weight > 3T)

P = no. of vehicles/ day at the last count

R = annual rate of increase of vehicles

n = no. of years between the last count and the year of completion of construction.

- The design thickness is considered applicable for single axle loads up to 8200 kg and tandem axle up to 14500 kg for higher axle loads, the thickness is further increased.
- When sub base course material contains substantial proportion of aggregate size above 20mm, the CBR value of the material would not be valid for the design of subsequent layers above them.

LIMITATION:

The CBR method gives the total thickness requirement of the pavement above a subgrade and this thickness value would remain same irrespective of the quality of materials used in the component layers. Thus, the component of materials should be judiciously chosen for durability and economy.

ESTIMATION:

- An estimation is a computation or calculation of the qualities required and expenditure likely to be incurred in the construction of a work. The primary objective of estimate is to enable one to know beforehand the cost of the work.
- For all engineering works, it is desirable to know beforehand the probable cost of construction known as estimated cost. If the estimated cost is greater than the money available, then attempts are made to reduce the cost by reducing the work or changing the specifications. In preparing the estimate, the quantities of different items of work are calculated by simple mensuration method and from these quantities, the cost is calculated.
- Accuracy in estimate is very important, if an estimate is exceeded, it becomes a very difficult problem for the engineers to explain, to account for and arrange for the additional money. Inaccuracy in preparing of estimate, omission of items, changes in design, improper rates etc., are

the reasons for exceeding the estimate, though increases in rate is also one of the main reasons.

- The rate of each item should be reasonable and workable. The rates in the estimate provide for the complete work, which consists the cost of the materials, cost of labour, cost of tools and plants, cost of water, taxes, establishment, supervision cost, reasonable profit of contractor etc...,

SIGNIFICANCE OF THE STUDY:

This research can be used as a spring board for further studies for those who are interested in the area. On the other hand, the study can help users to choose appropriate methods for a given task. Moreover, since coordinates of the reference points are determined with high precision, it can be serves as a reference value for other users.

SCOPE AND LIMITATION OF THE STUDY:

The scope of this study is limited within evaluating and comparing the accuracy, precision and time expenditure of three surveying methods. Determining and evaluating the accuracy of the measurement need quite stable weather condition and carefulness. During this work there have been a lot of limitations especially related with whether condition (cold, snow and wind). Due to this problem, the study could not complete according to the time frame work.

THESIS OUTLINE:

Chapter one introduces the overall background, problem, and objective of the thesis. Chapter two starts with literature review, which describes the overview and fundamentals of GPS, total station, and laser scanner. It also presents

other's related work. Chapter three introduces methodology of the thesis and procedures. Chapters four presents the result and discuss the result in detail. Chapter five gives conclusion and recommendation that can improve the result.

LITRATURE REVIEW:

This section describes some of what others have done in related work in order to give brief idea about the overall concept of precision, accuracy and time expenditure of total station, GPS and TLS. According to the work by Ehsani et al, (2004), a 50-ha area was surveyed with RTK-GPS. The base station and four reference points were established over the highest point in the survey area. Corrected GPS signals are transmitted in real time from a base receiver at a known location to one or more rover receivers. Results from RTK GPS method, a horizontal coordinate accuracy of 1 cm has been achieved by compensating for atmospheric delay, orbital errors and other variables in GPS geometry. Comparing this thesis with the above work, 8 mm horizontal coordinate accuracy achieved using the same method (RTK). According to Lin, (2004), accuracy test was made between GPS RTK and total station. The results showed that a positional accuracy of 14 mm has been achieved using GPS RTK while using total station it was possible to determine 16 mm positional accuracy. Any blockage from natural or man-made obstacles such as trees and buildings can make use of RTK method limited or impossible. In such cases, total stations are used. Borgelt et al, (1996) compared the accuracy of RTK with total station on the free area and they reported a standard deviation of 12 cm in a vertical position with RTK. But in the case of total station, better results (below 5 mm) have been achieved. P. flipsen, (2006), has tested accuracy and time expenditure of total station versus laser scanner on a pile of sand for comparison purpose. The pile was surveyed twice: once with a laser scanner (Leica HDS 2500) and once with a total station (Leica TS1200), and he processed the data in Cyclone

and Geo software respectively. His result showed that almost similar horizontal and vertical coordinate accuracy have been achieved below 9 mm in both methods. The time consumed for the measurements was a little bit more (7 minute) for the total station. According to the studies conducted by Jonsson, et al (2003), RTK measurement was applied to test accuracy of different GPS instruments (Leica, Topcon and Trimble). A network of nine control points was established using total station. Then, the authors performed RTK measurement on the same network and compared results with different instrument. Results obtained from RTK measurement have shown a horizontal and vertical accuracy of 10 mm and 2 cm respectively. When comparing this result with the result of the thesis, better accuracy was achieved in both horizontal and vertical coordinates. In order to check the compatibility of the RTK method with that of total station method, Ahmed, (2012) tested RTK and total station measurements on an existing network. The objective of the test was to assess the RTK achievable accuracy, to check the repeatability of the results under -14- different satellite configurations and to evaluate RTK performance in urban area. In the test, accuracy, and repeatability assessment of the RTK was carried out by comparing the coordinates of points with that of independently precisely determined using a total station. According to the result, the difference between the coordinates of total station and RTK was 2 cm for the horizontal and 3 cm for the vertical coordinates. In comparison with the results of this thesis, the coordinate difference between total station and RTK (coordinates of RTK-coordinates of TS) was 1.8 cm for both horizontal and vertical coordinates. In another study by Foregoes, et al, (2007), the objective of the study was to access the feasibility of monitoring deformations of large concrete dams using terrestrial laser scanning. For this purpose, a test field has been established on the specific dam. First the author established a geodetic network as a reference by Leica TS, and then, using a few targets on the dam, measurements were taken with a total station and a laser scanner. The reference network was

determined with 2 mm horizontal and 3 mm vertical coordinate precision. Targets, mounted on the dam, were measured precisely with a total station, and 3 mm for the horizontal and 4.5 mm for the vertical coordinate accuracy (RMS) has been achieved. On the other hand, using a laser scanner (HDS 300), 4 mm for the horizontal and 8 mm for the vertical coordinate accuracy (RMS) was achieved.

METHODOLOGIES OF SERVEY WORK:

Establishing Reference Network:

In order to evaluate the accuracy and precision of the surveyed data, primary it has been established a network of control points which can serve as a reference for comparison with RTK and TLS measurement. The reference network was established fourteen control points using a Leica 1201 total station. To determine the network with high precision, measurements have been taken in two faces with two rounds. Four points of the reference network were also measured with static GPS in order to transform the datum from the local coordinate system to the required coordinate system, SWEREF 99. Thus, this network served as a reference value. The precision of the remaining RTK and TLS measurements were evaluated depending on this reference value. Therefore, to accomplish the objectives of this project, data were collected from field measurement. The field measurements were taken using three different surveying instruments: - Global Positioning System (GPS), laser scanner (LS) and total station (TS). To eliminate instrumental errors such as line of sight errors, tilting axis errors and vertical index errors (see Table 3.3), two face measurements were taken. Since the coordinates determined with total station are provided in local coordinate system, static GPS measurement was needed to transform the datum to SWEREF 99. Then, precision of the network has been obtained from network adjustment and verified for if there have been gross errors were occurred. Detail measurements (RTK on the network and, TLS and

TS on the façade) were taken five times to evaluate the precision of the measurement. Finally, accuracy and precision of the detail measurements were tested by RMS and standard deviation analysis respectively.

Evaluation of Accuracy and Precision:

To evaluate the accuracy and precision of the measurement, RMS and standard deviation of the individual measurements were computed. RMS (root mean square error) is a measure of accuracy of the individual measurement. It can be computed from the deviations between true and measured values. True value of the measured quantity is the value which was determined with significantly higher precision. In this project the coordinates of the reference network were considered as ‘true’ which is determined in 1mm level. RMS was computed using the following formula:

$$RMS(l) = \sqrt{\frac{\sum_{i=1}^n (l-l_i)^2}{n}}$$

Where: L is the established value, l_i is individual measurement and n is the number of measurements.

Standard deviation is a measure of variations of the repeated measurement, i.e., of the precision of each individual observation. It can be computed from the mean values of the individual measurement and the individual measurement. Standard deviation is computed using the following formula.

$$SD(l) = \sqrt{\frac{\sum_{i=1}^n (l-l_i)^2}{n-1}}, \bar{l} = \frac{\sum_{i=1}^n l_i}{n}$$

Where: L is true or established value, l_i is individual measurement, \bar{l} is mean value of the measurements and n is number of measurements.

Choosing suitable control points for the network and detail survey:

Reconnaissance of the project area was the first step in the establishment of control network and followed by marking fourteen control points which are visible each other. Those control points were also suitable for satellite visibility, because RTK method was needed to compare with the TS control points. The points are marked with nails for sustainability reason. The project area was close to L building in the campus of KTH, Stockholm, Sweden.

Setting up targets for laser scanning:

In order to compare the results from total station and laser scanner, 21 target points were chosen at the North Eastern façade of the L building. Six black and white target papers were marked as control points for the registration of Scan Worlds. Those target points were also measured with total station. There are requirements to be fulfilled when choosing black and white targets. As Quintero et al, (2008) stated out, not only is the station position important, the positioning of the targets carries equal importance. And so, it is important to note that:

- targets be widely separated;
- targets have different heights;
- as few targets as possible on one single line;

OVERVIEW OF SURVEY WORK:

- The project area is the parking lot close to Main gate, Gift college. First, reconnaissance of the project area has been performed, and followed by establishing a network of 14 control points, which have been used as a reference value for the detail survey. The network has been established using Leica 1201 version total station.

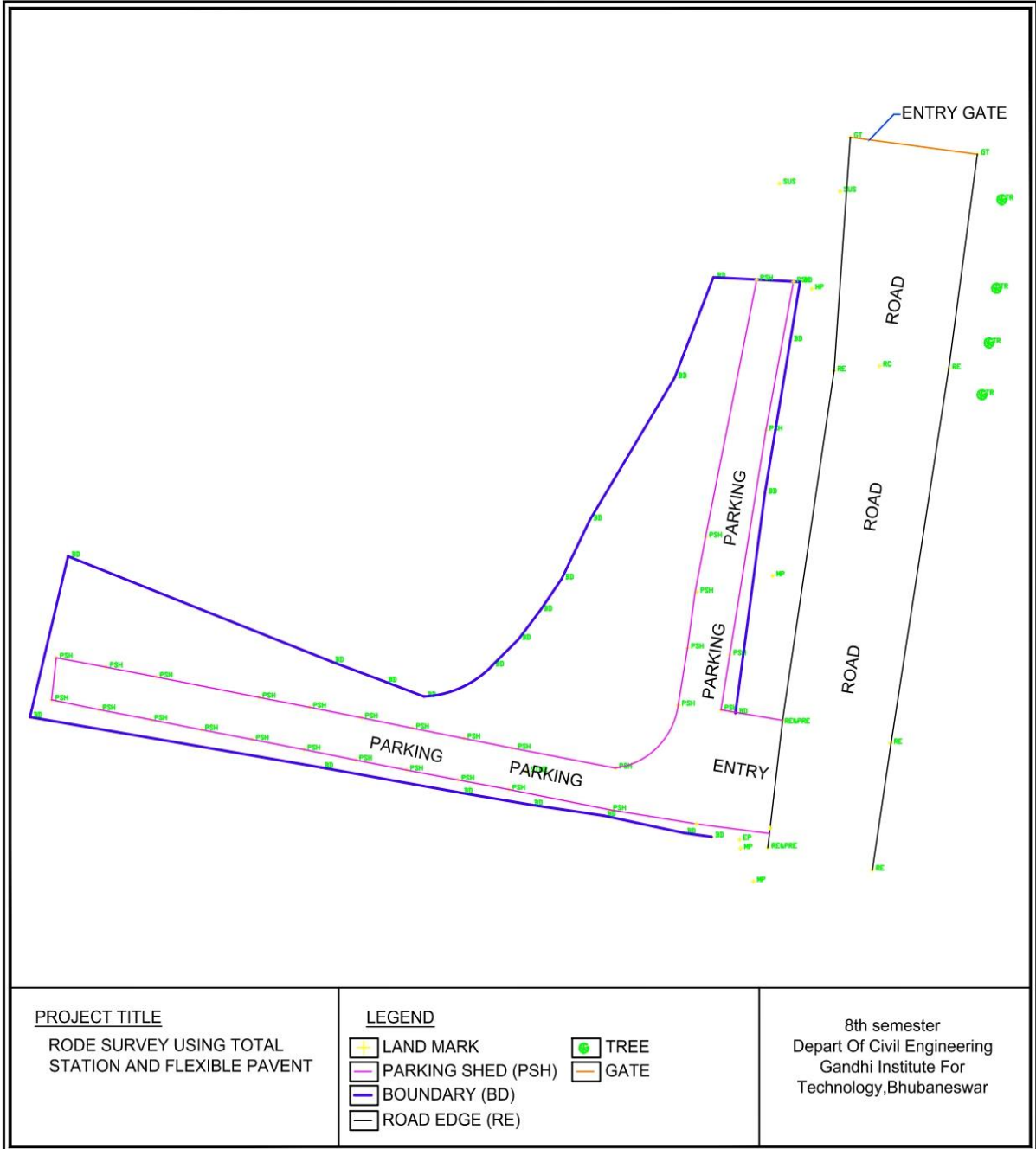


Adjustment:

- Adjustment is an improvement of the measurement, since measurements are not free from errors. Improvements to observations and coordinates for new points are calculated with various quality measures such as standardized residuals, standard deviation, redundancy numbers, error ellipses etc. The reference network was adjusted first with free adjustment in order to eliminate any contradictions in the fixed points

Rounds of Measurement:

- For the sake of eliminating or at least reducing errors emanating from collimation axis error, vertical axis error, compensator errors (longitudinal and transverse), vertical index errors, two face measurements with two rounds have been taken. Mean values of the two face measurements were checked if their differences were below 2 mm for distance and 6 mgon for angles. Atmospheric corrections were also applied before adjustment.



(AutoCAD Drawing)

METHODOLOGY FOR PAVEMENT DESIGN:

Collection of samples:

Three samples of soils had been collected in the location of the site (work).

Types of Tests:

The different types of tests conducted on the samples are:

(a) Index Properties

1. Liquid limit
2. Plastic limit
3. Specific gravity
4. Sieve analysis

(b) Engineering Properties

1. Standard Proctor test

CALIFORNIA BEARING RATIO (CBR) TEST:

The CBR test is a penetration test developed by the California division of highways, as a method evaluating the stability of soil sub-grade and other flexible highway materials. The test results have been correlated with the pavement thickness requirements for highways and airfields. The CBR test may be conducted in the laboratory on a prepared specimen in a mould or in-situ in the field.

Procedure

- About 5kg of oven dried soil sample is taken and is mixed with optimum moisture content. The soil is then compacted either by IS light compaction (3 layers, 55 blows, each by 2.6 kg hammer) or IS heavy compaction (5 layers, 55 blows, each by 4.89 kg hammer).
- The mould with the base plate is placed under the penetration plunger of the loading machine and a surcharge weight of 2.5 kg is applied.

- The dial gauge for measuring the penetration values of the plunger is fitted in position. The dial gauge of the proving ring and the penetration dial gauge are set. The load readings are recorded at penetration readings of 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0 etc.
- The proving ring calibration factor is noted. The load penetration curve is plotted. The unit load values corresponding to 2.5mm and 5.0mm penetration values are found from the graph.
- This load is expressed as a percentage of standard load values at the respective deformation level to obtain the CBR value. The CBR for 2.5mm penetration is taken.

The standard load values

Penetration (mm)	Standard load (kg)	Unit standard load (kg/sq.cm)
2.5	1370	70
5.0	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

CBR value is calculated by the formula,

$CBR = [(Load\ sustained\ by\ specimen\ at\ defined\ penetration\ level) / (Load\ sustained\ by\ sustained\ crushed\ stone\ at\ same\ penetration\ level)] * 100$

Observation and calculation

S. No	Penetration(mm)	Proving Ring Reading	Load on plunger(kg)
1	0.5	0.8	42.56
2	1.0	1.6	85.12
3	1.5	2.4	127.68
4	2.0	3.2	170.24
5	2.5	3.7	196.84
6	3.0	3.8	202.16

7	3.5	3.9	207.48
8	4.0	4.0	212.8
9	4.5	4.2	223.44
10	5.0	4.3	228.76
11	5.5	4.4	234.08
12	6.0	4.6	244.72
13	6.5	4.8	255.36
14	7.0	5.0	266.0
15	7.5	5.1	271.32
16	8.0	5.2	276.64
17	8.5	5.3	281.96
18	9.0	5.4	287.28
19	9.5	5.4	287.28
20	10.0	5.5	292.6

$$\text{CBR}_{2.5} = (196.84 / 1370) * 100 = 14.36\%$$

$$\text{CBR}_{5.0} = (228.76 / 2055) * 100 = 11.13\%$$

The CBR value of soil sample = 14.36%

DESIGN OF PAVEMENT THICKNESS BY GROUP INDEX

METHOD:

Sieve analysis:

Mass of soil taken = 500gm

Mass of soil passing through 75 μ sieve = 6gm

Percentage finer = (mass of soil passing through 75 μ sieve/mass of soil taken)

*100

$$= (6 / 500) * 100 = 1.2\%$$

Liquid limit = 24%

Plastic limit = 14.28%

GI = 0.2a + 0.005ac + 0.01bd

Where,

a = percentage of material passing through IS 200(75 μ) sieve more than 35 and less than 75

b = percentage of material passing through IS 200(75 μ) sieve more than 15 and less than 55

c = liquid limit more than 40 and less than 60

d = plastic limit more than 10 and less than 30

Here, a = 1.2 – 35 = 0

b = 1.2 – 15 = 0

c = 24 – 40 = 0

d = 14.28 – 10 = 4.28

GI = (0.2 * 0) + (0.005 * 0 * 0) + (0.01 * 0 * 0)

= 0

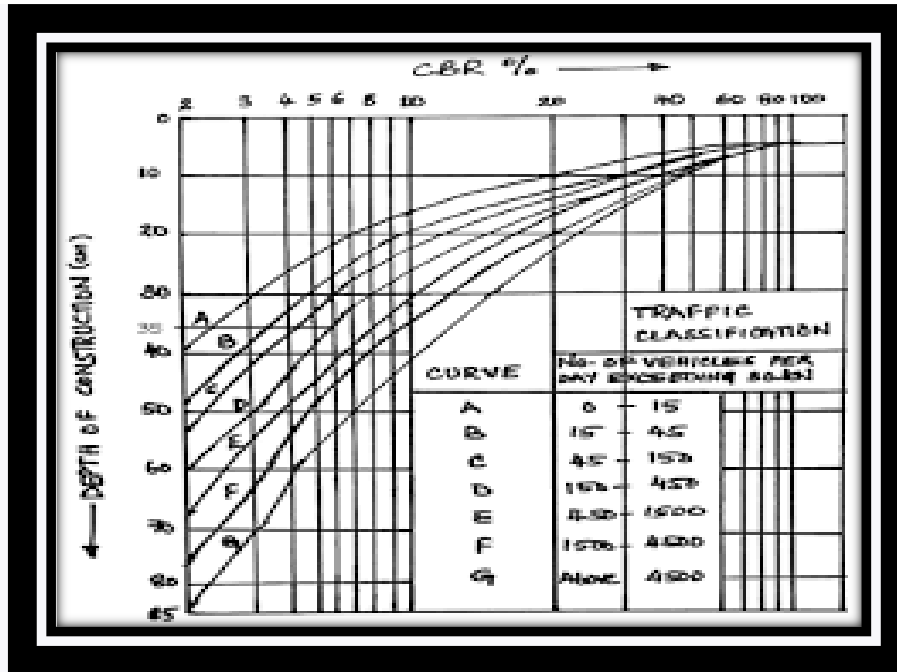
Assuming the traffic to be medium, 50 to 300 vehicles per day.

From the design charts, the combined thickness of surface, base and sub-base course = 23cm

The thickness of base and sub-base courses = 20cm

DESIGN OF PAVEMENT THICKNESS BY CBR METHOD:

- The soil samples are taken and their optimum moisture content is determined by Proctor's density test for light compaction.
- The soil sample is then compacted in CBR mould for optimum density and the mould is soaked for 3 days.
- The CBR test is then performed to obtain the CBR values for the soil sub grade.



(fig.6 CBR design chart)

CBR corresponding to 2.5mm penetration = $(74.4/ 1370) * 100 = 5.4\%$

Assume, Average Daily Traffic (ADT) = 300

Annual rate of growth of traffic (r) = 8%

Time taken for pavement construction (n) = 1 year

No. of vehicle for design (A) = $P (1 + r)^{(n+10)}$

$$= 300 (1 + 8/ 100)^{(1+10)}$$

$$= 699.49 \text{ vehicles/ day}$$

- Therefore, Design Curve E is to be used for design as the design traffic volume is in the range 450 to 1500 vehicles/day.
- Using the design chart, the total pavement thickness over subgrade having CBR of 5.4% is obtained as 40cm for curve E.
- Thus, 40cm of pavement materials is required to cover the natural soil subgrade having 5.4% CBR value.
- Therefore, the thickness of base and sub base courses are 12.5cm and 22cm having CBR value 55% and 25% using the design chart.
- The CBR values for the gravel and road metal are assumed as follows:

Types of material	Suggested CBR values (%)
Gravel	25
Road metal	55



CONCLUSION:

- In this project work, an attempt is made to incorporate latest techniques of geometric design, pavement design for a bike parking which lies within the premises of GIFT college, BBSR. The IRC specifications are based on rational thinking, the proposed design is safe in both geometrics as well as pavement design.
- It is also proposed to design a flexible pavement by Group Index method and CBR method. Some more methods are available in the design of flexible pavement, which are much advanced like California resisting value method, Mc leod method, Triaxial method and Burnister method. Because of the limitations of time and scope, only GI method and CBR method are adopted.
- To have a practical concept of estimation analysis, an attempt is made to estimate the quantities of each work of flexible pavement.
- Today total station (TS) is used for many tasks within different applications, for example, geodesy, engineering, architectural and mining surveys and documentation of cultural heritage with different accuracy level depending on the needed requirements.
- The purpose of this is work was to evaluate and compare accuracy, precision and time expenditure of total station surveying method.
- The project area is the parking lot close to Main gate, Gift college. To accomplish the objectives of the thesis, three major tasks have been performed.
- 1. A network of 14 control points was established with high precision (1 mm) with total station and served as a reference or established value.

RECOMMENDATIONS:

- The obtained results from this thesis will hopefully improve the knowledge about accuracy, precision and time consumption of the TS method used. One can differentiate which instrument should be used for which specific application depending on the presented results. For further improvement of accuracy, the following recommendations are forwarded:
- Total station (Leica 1201) should be calibrated at some regular intervals. Since there was problem in the level bubbles; one on the tribrach and the other on the total station couldn't be levelled at the same time. So, once calibrated the instrument, it will improve the level of accuracy.
- It can be achieved better accuracy by calibrating those instruments before the measurement campaign.
- Applications which require high precision to serve as reference value, such as control point establishments, I recommend to use total station instead of GPS.
- It was very difficult to manage the field measurement alone, specially establishing the reference network has been a big problem. There will be a possibility of occurring gross errors and therefore, I recommend working in group.

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