GENERAL CONCEPTIONS FOR CONSTRUCTION OF A RAILWAY

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1-INTRODUCTION

During the construction of a railway line two different phases should be taken into consideration ;
1-construction of the substructure; which because of the great earth volumes usually moved, in railway projects,contributes quite significantly to the total cost of the work . Aand
2--onstruction of the superstructure.

2- Construction of the substructure :

In order to focus better the activities related to the construction of the sub structure ,it was desided to consider the start of the work from the geografic services that aim to guide the preparation of the final engineering design to be materalized in the field .

2-1 Topografic services:

Among the topografic services which are essential to the project detail ,the following should be stressed :

-Axle location and tieing.
-Levelling and counter levelling of the location axle .
-Servy of the cross section .
-Additional topografic survey , such as :

- intersections and approches.
- areas for installation of yards,stations ,shops,service stations,etc.
- Structure and special structure.
- Right of way record .
- Topograffic of occurrences.

2-1-1- Axle location and tieing

The axle location and tieing is done from the illustration of the important points of the horizontal conformity curves(pi ,pc,pt,cs,sc)by means of polar coordinates and from the secondary polygonalvertices(ps),previously implemented,of the Topografic Basic Network. Once the important points of the geometric designaxle are materiaized,the location is made withthe use of a range finder or theodolites with the linear measures taken by of steel tapes ,

Normally the axle is picketed every 20 meters ,In allpickets implemented ,core piles must be placed , made up of good quality wood about 60 cm long ,provided with grooves where the cooresponding number will be written with oil paint , down wards .these piles are located always at the left of the piling , in the ascending direction of it is numbering and with the number turned to the picket. The radius curves smallerthan 600meters are generally picketed every 10 meters.All pickets corresponding to the pI, pT, andsc ,as well as the pickets every 2 Km from the long tangents , are tied by safety points" located more than 20 meters from the railway axle.

The tieing process is usually made by eight marks. Then tieing books are organized ,where the tied points are recordered .

Installation of the axle is made of two different phaces :
-tangent installation
-curve installation The lengthmeasures can be taken with the steel tape ,based on the horizontal , for the purpose of installation of the location line pickets,

The curves are materialized in the field , using theodolite.
The deflection process on the tangents may be used.

2.1.2 -Levellingand counter levelling of the Location Axle

The next step will be the geometric le velling and counterlevelling ofall pickets of the location axle and inall the RRNN of the levelling Basic Network. Establishing ,in this manner.
The althymetric control of the line.
The levelling error tolerance is ,in general , 2cm per kilometer and the maximum accumulated differerence lower or equal to that obtained by the formula:
e=12.5 sq root of(n)

having

(n} in kilometers
(e)in millimeters
Togeather with levelling the important thing of the existing water course crossings are levelled and counter levelled , recording inthe levelling book ,the water mirror level, on the levelling date, and the maximum flood levell .
The water course bottom will also be levelled , in order to permit drawing of the crossing longitudinal profile, to be used inthe structural design .

2.1.3 Cross section survey

Cross sections are then serveyed in all pickets of the located axle , by using rulers , level or theodolite .

The sections will be surveyed symmetrically ,in relation to the axle and so as to cover the limitis of the future right –of-way.on points where it is necessary to make special studies ,the sections will be extended as deemed sufficient for those studies . whenever necessary , The spacing between the cross sections will be reduced to (10) meters.
The recording books of the cross sections must include :houses quarries ,secondary vally bottoms, river banks, dividing fences and remaining accidents crossed by the sections.

2.1.4 Additional topographic surveys.

2.1.4.1 Survey of Intersections and Approaches.

In general all approach locations and intersections will be surveyed with the purpose of making the detailed study .

2.1.4.2 Survey of areas for installation of :
a)yards and stations :
b)shops, service stations, etc..

2.1.4.3 survey of water Basins
In order to make the revision studies of the water basin areas,it may be necessary to make additional topographic survyes in the field.

2.1.4.4 Location of the special and current structure to be constructed .

The special structures will be topographically and bathymetrically (every 5m) surveyed in addition to the river bottom profile in a length of 100 m, to each side of the axle , the longitudinal sections of the talweg will also be surveyed,with the purpose of designing the cave culverts .

2.1.4.5 Right-of –way book

Simultaneously with the location , or soon after wards, the listing of all areas cut or crossed by the rght- of –way specified by the design axle will be proposed .

On books prepared specifically for this type of work the names of the owner s,existing constructions and nature of improovements covered by the section will be annotated . at this point , information will be obtained from the residents of the buildings affected , on the legal situations of the deeds .

2.1.4.6 Topographic survey of the occurrences

The topographic survey of all occurences of materials selected by the geotechnical studies for the ballast and sub ballast and the borrow pits concentrated tobe used in the fill body and higher earthwork layers , will be carried out.

The topographic survey of the occurrrences is made with the help of auxiliary poligonals , and sections should be surveyed so as to permit their drawing with level curves spaced every 5m .

All occurences are tied to the progect location axle.

Specific books should be prepared for this type of survey , with tieing sketches of these occurrences.

The above described topographic services are then consolidated in the following documents:

-plan at the 1:2000 scale , with level curves every 1 m.indicating all accidents and occurrences surveyed ;

-profile of the location line at the 1:2000 (H) and1:200, (V) scales.

- drawing of the cross sections at the 1:200 scale ;

-drawing of the survey of the occurrences of materials , water courses , intersections , etc .

From these elements , the final progect detail is made for examination of the sub structure , subject of the following items.

2.2 Geometric design

2.2.1 Plani- althymetric design

a) On plan

Axle piled every 20m marking the corresponding piles to the full kilometers; as well as the piles corresponding tothe hundreds of meters .

The alighment routes and the numbered curved are indicated, with their elements, on auxiliary tables.

The line safety points will all be tied ,organizing for them , side sketches ,doing the same with the RRNN that will have their locations and levels marked on the design .

The platform rims and the dotted- line offset projections are shown in the proper stipulations , indicating cuts and fills .

Further , the transmission lines inside the Rights-of-way are represented , indicating the orignand number of poles .Bridges , crossings and service facilities, with thenames of the places , indicating the volume number and of the sheets containing the specific designs .The culvertsw are indicated in stipulation types (dotted lines)with their total length at the foot of the fill and it is slopes.

Other devices (protection ditches),counter-rivers), borrow pits) are represented ,indicating the location where the construction details are found .The right-of –way will be represented in all planks , indicating the limits and their ordinates in relation to the axle .The althymetry of the area – comprised by the right –of –way is shown by level curves,which ,on plan or not toowavy soil will have intervals of 1.00m or less,so as not toleave aspase greater than 2.5 cm without visualization in the original drawing ,on size A-1; in the wavy , strongly wavy and mountain region,Level curves will be indicated every 5m .

b-On profile

The soil and design line will be indicated , representing the grade surface of the earth work platform axle . There are indicated the elevation percentages and it is lengths,the length of the horizontal projections of the vertical conformity curves (Y), the length of versine (e) of the vertical curves, kilometers and levels of the PIV, PCVand PTVof each vertical curve. There will be represented by stipulation s-type the special structure and culverts , indicating for the latter their type and section ,and the drainge devices by stipulation lines.Also the geotechnical profile must be represented with the soil classification .The profile will also point out the extensions with specific solutions (diverting from the cross section type) for widening of the cuts,staggering or change in the slope inclination, etc.

2.2.2 Typical Cross sections

Thered are prepaired and defined:typical cross sections of the platforms , right- of – way, bridges and tunnels in the different characteristics forecast for the railway on tangent and on curve ,showing the distribution criterium of the super elevation along the horizontal curve conformity .

2.2.3 Cross sections

The cross sections are drawn indicating the natural soil, the platform,the offset and slope position .

2.2.4 Right-of-Way

The right- of -way is marked in relation to the axle and is based on the offset line.

2.2.5 Earthwork Work Notes

In the first sheet of the (Service Notes) there will be shown sections, types of cuts and fills ,with indications of all elements included in the table .

The sheets of (Service Notes) must include the piles of all reference points of the longitudinal axle, on plan and profile , pointing out the curve and transition points, as well as levels and distances from the axle of all points defining the cross sections and the offsets.

2.3 EARTH DESIGN

The earth work design is made of:

-Computation of the earth movement volume.

-Forming of the fills,indicating the origin of the materials to be used in their various layers and the degree of compaction to be followed ;

-Computaion of the transportation distance ;

-Details showing the cross section type and the specific solutions of slope inclination,widening of cuts,yards, fill foundations,etc.

The fill material must be obtained,whenever possible,by means of cut widening;
If thisis not possible , borrow pits must be searchedout side of the right-of-way.

Under any circumstances, you must have in mind the consequences of locating these boxes in future railway improvements.

2.4 GEOTECHNICAL STUDY

The geotechnical study consists basically of:

-Sounding and collection of materials in the field.-

-Making of tests in accordance with Testing Manuals and Methods ,belonging to the client , or accepted by him.

During the studies,the main activities are pointed out, as follows:

2.4.1 Sub-bed study

Along the geometric design location the following is carried out :

a)Soundings and collections, removing the samples to characterize the material to 1m below the geometric design grade , defining the geotechnical profile of the soil . The soundings are made along the axle located with spacingsevery 100 meters and in the intervals, when there is variation of material .

b)with the material collected in the soundings the following tests will be made :

-grain size with sedementaion ;
-physical indices;
-compaction ;
-ISC
-density in place .

The first two tests are normally made in all welding bores, while the last two are made in alternated bores.

c-The sub –bed soundings must be included in the profile of the located axle .

2.4.2 Borrow pit study for the fill Body

*a)*The selection ,in the field , of the borrow pit areas , is made from the indications of the Earth work Design .

In places where side borrow pits are forecast, the test bores will be located,in principle in the borrow pit axle, the longitudinal distance between the sounding bores being 100m and the depth equal to that fore cast for the borrow pit .where concentrated borrow pits are forecast, at least five bores will be made , distributed by the borrow pit area, with depth equal to that forecast for the borrow pit . For borrow pit boxes greater than 10,000 sq m ,dotted lines will be prepared with mesh of 50m on the side ,where bores will be made with a maximum space among them of 70m.

Samples of all bores will be collected in the different horizons to witch the following tests will be made ;

-grain size.
-physical indices;
-compaction.
-california support index.

NOTE On the side pits the compaction and ISC tests will be made every 200 meters.

b) Along the full project length ,tests will be made to determine the apparent specific mass in place , so as to have elements to define the fill/cut contraction factor.

2.4.3 Study of Occurence of selected materials

In the study of occurrence of materials for paving , the following is pointed out;
-Quarries, sands, gravel ,gross sand, and deposits of soil materials;

a)In the occurrence of gravel , gross sand and soil materials , deemed usable in the preliminary project phase, the final studies will be made, as follows ;

-soundings;
-laboratory tests ; and
-volume

Once the possibility of technical-economic use of an occurrence is verified ,based on the laboratory tests made in the samples collected in the drillings made according to the preliminary prospection, its final study and it is volume will then be made . F

or this purpose, dotted lines will be prepaired with mesh of 30 meters on the side , within the limits of selected occurrence on the numbered vertices of wich the sounding drills will be made .

On each of 30m mesh , for each layer of material, aGrain size testby single screening, of Liquidity Limit, Plasticity Limit and sand Equivalent, and in alternated bores, Compaction Tests, ISC and Density in place, will be made .

Plans of occurence of materials, as well as corresponding soil profiles.

In the event that there are layers with more than 1.00 of thickness, the above mentioned tests should be carried out, for each meter of depth of this layer.

The number of minimum samples tobe researched in an occurrence will be (9)after the rejection of the spurius values with deviations much above the standard deviation.

b)In the occurrences of rocky materials, the following tests will be carried out;

1. Los Angles Abrasion;
2. Durability
3. Sheet test (for basalt rocks)
4. x-ray diffraction (for basalt rocks).

c)In the sand deposits the following tests will be made ;

1. grain size
2. organic material content.

2.4.4 Fill foundation study

Any time there is any doubt in the supporting capacity of the fill foundation soils, it will be necessary to develop a special geotechnical study which will define the supporting capacity of the natural soil .

This study will consist , basically, of the following tests;
-determination of the layer thickness;
-determination of the natural moisture;
-determination of the apparent specific mass.
-determination of the grain actual specific mass;
-grain size ;
-liquidity limit
- plasticity limit
-resistence to the single compression
-thickness;
-quick triaxial.

NOTE; When Justified, the tests of Resistance to compression
(single and quic triaxial)may be replaced by vane shear test.
The technical-economic comparisions may be made for the diffrent fill solutions on compressible soils,even comparing the fill solutions on compressible soils,even comparing the fill solutions with concrete structures .

2.4.5 Stydy of the foundation locations of the special structures

The soundings for special structure foundations are made according to the following methodology:

a)selection of the locations where the structure will be placed :

b)preliminary soundings ,in order
to define the structural type to be adopted in the work:

c) Final soundings.

2.4.6 Slope stability study

The section which is being designed, from the stand point of slope stability , should be divided into homogenous sub –sections and on each one of them there will be investigated ,by sampling , the behavior of the cut slopes higher than 5.00m.The same care should be exercized in the studies of the borrow pits and deposit of excavation excess locations.

Investigation of the slope stability must be preceded by a general plan of the study, to be approved by inspection before it is actual start in the field .

2.5 DRAINGE DESIGN

The drainage design will be made up off:-

-Conception of the structurees which will make up the surface and deep drainage design;

-Definition of the drainage structure ;

-Preparation of Service Notes of the different services making up the drainge design,showing:the location,type,size and lengthof the work .

2.5.1 Conception of the Drainage Devices

2.5.1.1 Surface Drainage

The surface drainage system has the purpose of impounding and intercepting the waters that fall on the road, and take them to a safe discharge place ,without hurting the stability of the road , and causing erosion in the neighboring areas .

The surface drainage system is made of the following devices :
-cut protection ditch;
-fill protection ditch;
-soil cut gutter;
-rock cut gutter;
-fill bench;
-water discharge;
-water fall;
-collector box;
-dampening box;
-slope .staggering;

2.5.1.2 Culverts

The purpose of the culvert system is to allow the passing of the waters that flow through the natural soil , from one side to the other of the road body and as an additional device, supplementing the surface drainage,when indicated as grade culvert.
The culverts used in railway will be of the following types;

-concrete tubular culverts
-metallic tubular culverts;
-concrete cellular culverts;

2.5.1.3 Deep Drainage

The deep drainage system has the purpose of intercepting and lowering the underground water , so as to prevent the progressive deterioration of the earth work layer support ;
-continous drains;
-discontinous drains;
-blind drains;
-intercepting drains;
-draining mattresses;
-hollow drains;
-crossing drains;
-trench drains.

2.5.2 Progect implementation

2.5.2.1 Tubular and Cellular Culverts

a)Individual definition of culverts;

b)Progect type based on the project discharges, obtained from the hydrologic studies,containing all the elements and construction procidures based on the heights of the fill,status of the road and characteristics of the foundation soil.Each progect should include the drawings of it is cross and longitudinal section ,it is structural elements and molds,hard ware and material consumption tables.

c)Location of the work ,with listing in the formof asummary chart showing for each work ; pile,type, total length,esconsity, final lengths of the culvert bodies at the left and the right , final level ofof the mouses, type of berth and/or special foundations , volumes to be ex cavated and backfilled , consumption of materials and additional remaks.

d)In the case of special soilor declivities for work implementation, submit aconstruction process for each work , with considerations on the type of the foundation, replacement of local material, implementation of giants , energy spreaders,etc.
ee)In the specific case of work to be extended , submit implementation details and construction phases , the general culvert chart should make refrence to these procedures,

f)In relation to grade culverts, show details of the collector boxes with all the construction systems and their implementations with the remaining drainge devices .

g) For the restoration process ,the existing drainge system must be examined in the form of the summery chart ;location, geometric elements , provable year for work implementation,status and type of foundation used ,present status of the culvert body , condition of the mouths, analysis of the work performance based on the basin to be drained , soil conditions up stream and down stream .

2.5.2.2 Surface drainage progect

The surface drainge will be made up of the following devices; cut protection ditches , fill protection ditches, soil cut, cut gutters, rock cut gutters, fill benches ,water discharges , spreaders, dampening boxes, river cutters, collector boxes , etc

a)Selection of the projects-type of the surface drainage devices with the purpose of collecting , transporting and final discharge ,with the difinition of all geometric elements of their cross section;

b)Determination ofthe lining types to be employed ;

c)Preparation of the progects –type drawings;

d)Determination of the discharge of each type of device ,showing methodology and clearing calculation memory.All geometric and physical elements must be supplied ; wet section area ,wet perimeter,hydraulic radius rugosity coefficient ,etc ,

e)Determination of discharges based on the imponding area .Valus must be tabulated for sections on curves and tangents. For this calculations the following should be clearly estabilished ;concentration time and recurrence period adopted;

f)Determination of the critical lengths ,considering the different grades of the railway longitudinal profile.These elementsmust be tabulated or submitted in the form of abacus, with the respective analytical solution ;

g)Preparation of a general chart for each type of device ,containing ; location(ends,side, etc), type , additional remarks such as; to be constructed , to be extended , etc;

h)Specifications of construction processes with the determination of qualities , by linear meter,and concrete mark , if applicable , etc

i)Considerations in relation to additional protection devices against erosion , with their location,solutions, specifications,quantities and remaining construction elements.

2.5.2.3 Deep Drainage Design

It may be divide into two parts:
-Deep drainage for soil cuts;
-Deep drainage for rock cuts ;
a)Submission of sounding bulletins of water level reserch ,with indication of the work time(rainy or dry season);
b)Progects –type of the indicated devices , showing cross longitudinal section, etc
c)Placingof the drains based on the platform to be implemented or additional platform;
d)Geometric definition of the drains ;

e)Characteristics of materials tobe used(porous pipes,drilled pipes,bore scheme, etc)

f)Making up, grain size and lengthsof the filtering layers;
g)Sketch indicating the origin of the materials making up the drains;

h)Construction processes for special cases(drains of the fish spine type drainging mattres, etc);

i)Details of the drains outlet systems (fill outlet,collector boxes, etc);

j) Summery chart of quantitative location;

k)On rock cuts, forecast the implementationof the draining layer, with location,type of layer,type of filling material,quantities,etc.

2.6 SPECIAL STRUCTURE DESIGN

The special structure designwill be made of;

-Design conception;
-Design structural calculation;
-Implementation plans.

With thefinal elements supplied by the topographic geotechnical,hydrological studies, and geometric design, the special structure design is prepared,made up of; calculation memory and executive drawings.

3- SUPERSTRUCTURE CONSTRUCTION

Once the substructure construction workis completed (earth work and substructure) in acertain section,including anypossible work ofre-composing and platform regulation,the superstructure construction will start.
On this chapter,we will focus on the superstructure construction as being only the line geometrymaterialization on the finished platform,since the construction methods proper are described under section p.

3-1 Location

Specifically, in the railway case, the final location requires special care because ,contrary to what happens in other means of transportation,it is of utmost importance that the final placing of the line be as close as possible to the design.
As amatter-of-fact in the highway case , for example,location errorsin the conformity of curves and straight lines,in the order of centimeters,is not so important because the vehicles that use the highway can, without any problem, try to follow adynamicallyconvenient route,thanks to the considerable slack existing between the actual axle of the circulation line and it is edges.In the railway case,the gauage tolerances are measured in millimeters and even so,are in the order of 2 to3m. In case these tolerance values are exceeded, in those points affected for such errors, in order to obtain the acceptable dynamic characteristics.

However, it should be stressed also that currently, thanks tothe availability of modern large – sizeline construction equpments, levelling and aliging machines, it is possible to obtain more easily and with high preccision, the minimum characteristics pre-established in the design.
As regards the operation itself of location of superstructure of arailway line, two main stages may be pointed out ; piling and implementation of reference marks of the alignment and levelling.

3.1.1 piling

The piling consist in the location of the axle and the line from the reference marks used during construction of substructure.

In this operation , piles are fixed every 20m or 50m on the tangents and 10m on the curve .On the circular curves radii higher than 600m, the piling may be spaced every 20m .

This operation is usually performed by means of theodolite, operating in such away that the first point of each alignment is common to the previous alignment (p1).Thus, on tangent ,points of discontinuity are avoided. On those piles previously placed ,the exact points that define the alignment are then marked .

With this procidure you obtain on a straght line the proper precision that on curves is only possible to obtainafter very difficult operations.

3.1.2 Implementation of Alignment and Levelling Reference Marks

Taking into consideration the fact that the construction of railway superstructure is made by stages,it is quite convenient that,in order to allow carrying out the line placing phases, alignment and levellingreference marks be implemented.
With this procidure, the location of the axle is transferred to the side of the platform, soas to permitplacing the track without any interference,
Such reference marks are implemented on a permanent basis on the side of the platform and away from the track axle not only to facilitate the fastening of the super structure in itis design position , but also on plan and profile , but especially to enable the futurre trac maintenance. Normally, these marks may be made of atrack on profile H, with pieces of used rails, placed vertically on a concrete foundation.

The mplementation of these refrences, on the curves , must be as accurate as possible, in such manner that the poligonal defined by the marks be acurve parallel to that of the design.

In the specific case of the (Baghdad-hsaibah) and(ALQaim-Akashat) railway,these marks were placed along the main line at adistance of 1500m from the face of the gauge the closest rail and as indicated below;

-in all important points of the conformity curve , both on plan and profile;
-On tangent every 250mand through the more favorable side of the track;
-On horizontalconformity ,circular and transition curves every 10m, and always by theinside of the curves ;

-In the center of the midway,when on double track sections with constant midway between two adjacent track centers;

-On double line section,but on variable midway in both lines following the above;

<u>NOTE</u>

Normally, the distance from the alignment and levelling reference marks must be higher than the recommended for the railway inthe question, since this position is in the area of influence of the blades of the ballast regulating machine.

On the reference marks are made the accurate markings of the points which define exactly the level of the lowest rail top, as well as the points actually away from the gauage line of the closest rail.

After the marks are placed , and in order to make the above mentioned accurate markings, In the specific case of Iiraq it was recommended to make the following verifications on curves , similar to thosemade to rectify the curves by versine method.

a)Atemporary marking expressing the constant distance from the gauge to the closest rail is made .

b)The versines are measured on each pile marked with 20m rope ;

c)The displacements that must be corrected are calculated;

d-Anew marking is made according to the above calculated displacements;

e)Anew checking by the versine method as indicated onb and c is made , until new di splacements are not necessary;

f) Then , make the final marking by means of the puncture.

The reference marks must also indicate the current superelevation.`

4-CLEARANCES

On rilway , it is very important to define the clearancees set up for the widest possibile vehicle which is going to run on the stretch. (See figure 1).

In dealing withstatic obstacles,the clearances are defined taking into consideration;
-safety margins capable of absorbing the slacks in the case ofbalance of the vehicles in movement;
-slack between wheels and rails ;
-Prominence of the rolling stock on curves;
-inclination of the vehicle because of the superelevation;
-minimum distances to be followed between trains that cross or between trains and isolated physical or continous obstacles along the track.

The general rule defines two clearances ; normal and minimum.

By definition, the normal rance is that which must be applied everywhere where it is allowed by the lengths of the right-of-way of the road ,or where there can be increased to reach the necessary width without any difficulty .In all other cases, and for speeds not higher than 90 km/h, aminimum clearance with smaller safety margins, called minimum clearance.

As regards the obtacle clearance , it should be further explained;

-it is accepted that the relative position of two adjacent tracks or one track in relation to outside obstacles, may vary between two maintenance intervention of routen rectification, under these circumstances, the tolerances accepted lead to increase in the clearance of 0.21m;

-the maintenance and rail and wheel wear tolerances may reach up to 0.04m. This value must be added to the width of the basic clearance;

-the prominences of the rolling stock on the curves are the parts of the clearance on a curve out side of the normal contour of the same clearance in a normal projection. There are two types;

Si=inside prominence of the curve.
Se= outside prominence of the curve.
These prominences are caused by the following factors;

-distances between the truck axles
-curve curvature I/R;
- car inclination at acertain point , based on the track superelevation ;
-the distance between two adjacent tracks must ensure , in addition to the above values, aminimum air sheet of 0.35m resulting from the crossing of two trains at 90 km/h.

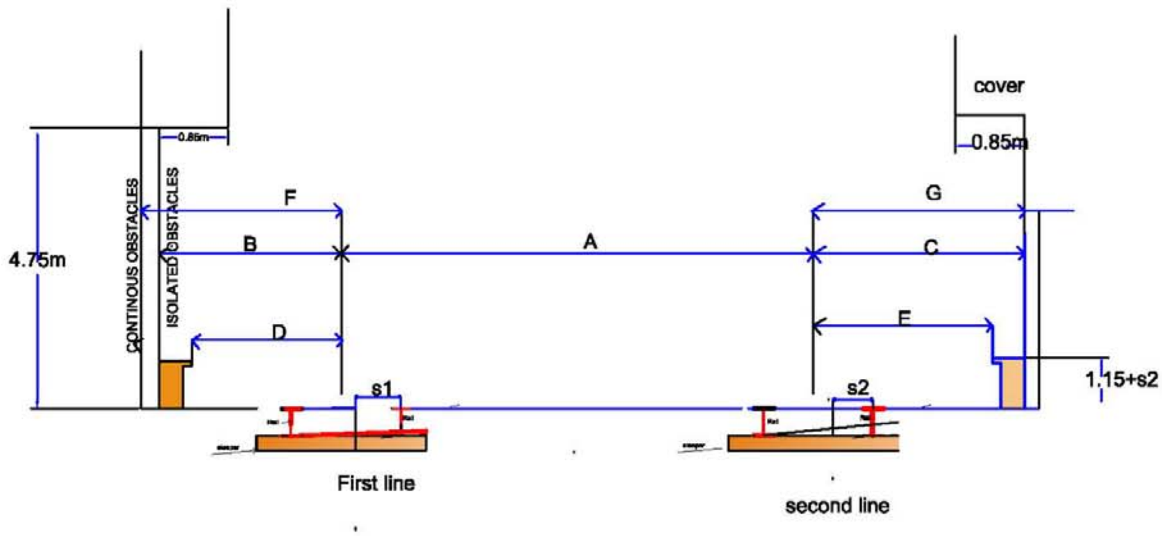

Figure 1

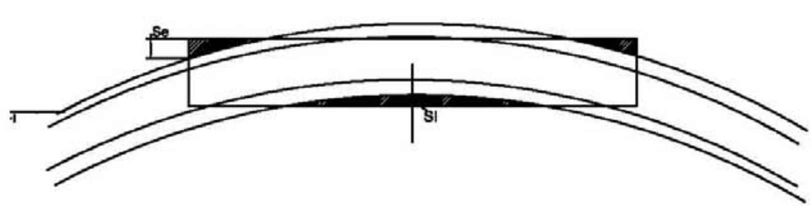

Figure 2