The arithmetic checks

The arithmetic checks must be done for all leveling calculations When establishing the heights of new Tabs and other important points, only BBS and FSP should be taken and the rise and fall method should be used. The HIP method of calculation can be much quicker when a lot of intermediate sights have been taken and it is a good method to use when mapping or setting out where many readings are often taken room a single instrument position. A disadvantage of the HIP method is that the check on reduced levels calculated from IS can be lengthy and there is a tendency for it to be omitted.

Precision of leveling As with all techniques used in engineering surveying it is important to estimate how accuracy of the measurements taken. An assessment of the quality of leveling can be made by calculating the enclosure for a line of levels. This is determined by comparing the reduced level of the closing bench mark with the level obtained for it by calculation from the staff readings. On construction sites ND other engineering projects, leveling is usually carried out over short distances and it can involve a lot of instrument positions.

The allowable enclosure for a line of levels is given by: Allowable enclosure = ?± m n Where, m is a constant and n is the number of instrument positions used. The value most often used for m is mm When the enclosure obtained from staff readings is compared to the allowable enclosure, if miniscule is greater than the allowable value the leveling is rejected and must be repeated. If the enclosure is less than the allowable value the leveling s accepted and the leveling is adjusted. The value of m depends on the site conditions.

For example if the levels found are to be used for earth work excavations m might be mom. For setting out steel and concrete structures excavations m might be mm. In some cases m is specified in the contract documents. Specifications for leveling are also given in: BOSSES: building setting out and measurement ICE Design and Practice Guide: The management of setting out in construction BOSSES: Guide to accuracy in building Sources of error in leveling There are three main groups of errors that can occur when leveling.

The most common errors fall into one of the following groups: 1. Errors in the equipment 2. Field or on-site errors 3. The effects of curvature and refraction on leveling Errors in the equipment Collimation error This can be a serious error in leveling if the sight lengths from one instrument position are not types of leveling all types of leveling, sight lengths should be kept equal, particularly back sights and fore sights and before using any level it is advisable to carry out a two-peg test to ensure the collimation error is within acceptable limits.

Compensator not working For an automatic or digital level, the compensator is hacked by moving a foot screw slightly off level, by tapping the telescope gently or by pushing the compensator check lever to ensure that a reading remains constant. If any of the checks fail then the compensator is not working properly and needs to be repaired. Parallax This effect must be eliminated before staff readings are taken. Defects of the staff The base of the staff should be checked to see if it has become worn - if this is the case then the staff has a zero error.

This does not affect height differences if the same staff is used for all the leveling, but introduces errors if two tiffs are being used for the same series of levels. When using multi-section staff, it is important to ensure that it is properly extended by examining the graduations on the other side of each section as it is extended. If any of the sections become loose the staff should be returned for repair. Tripod defects The stability of tripods should be checked before any fieldwork commences by testing to see if the tripod head is secure and that the base of each leg are secure.

Field or on-site errors Staff not vertical As the staff is used to measure a vertical difference between the ground and the plane of collimation, failureto hold he staff vertical will give an incorrect readings. Since the staff is held vertical with the aid of a vertical bubble, this should be checked at frequent intervals and adjusted if necessary. Unstable ground When the instrument is set up on soft ground and bituminous surfaces on hot days, an effect that is often overlooked is that the tripod legs may sink into the ground or rise slightly when the reading is being taken.

This then will alter the height of collimation and it is advisable to choose firm ground on which to set up the level and the tripod, and to ensure that the tripod is pushed ell into the ground. Handling the instrument and tripod As well as the vertical displacement, the plane of collimation of a level may be altered for any set-up if the tripod is held or leant against. When leveling, avoid contact with the tripod and only use the level by light contact.

Instrument not level For automatic and digital levels this source of error is unusual, but for a tilting level in which the tilting screw has to be adjusted for

each reading, this is a common mistake. The best procedure here is to ensure that the main bubble is centralized before and after the reading is taken. Reading and cooking errors Many mistakes can be made during the booking of staff readings taken with an automatic or tilting level, and the general rule is that staff readings must be carefully entered into the leveling table or field book immediately after reading.

Weather conditions In strong winds, a level can become unusable because the line of sight is always moving and it is also difficult to hold the staff steady. For these reasons, it is not possible to take reliable readings under these conditions which should be avoided when leveling. And other hard surfaces to ensure that the base of the staff remains at the same eight in between a back sight and fore sight. When the tripod is set up in soft ground or on tarmac on hot days it may sink into the ground or rise slightly when readings are taken.

This alters the height of collimation and causes errors. Try to set the level up on firm ground and always push the tripod legs well into the ground. The height of collimation may be altered if the tripod is held or pressed down Do not lean on the level, If the tripod is knocked it is necessary to re-level the instrument and repeat all the readings taken from that instrument position. Marking or recording the session of each change point on a long line of levels is advisable. If this is not done and the tripod is knocked all of the leveling will have to be repeated.

Curvature and refraction Over long distances level and horizontal lines through an instrument will diverge because level lines follow the curvature of

the Earth. This is a possible source of error in leveling since all readings are taken along horizontal lines instead of level lines. The difference between a horizontal and level line is know as curvature and is given by c = 0. 0785 DO Where, c = curvature in meters, D = sighting distance in km The correction for length of sight of mom is less than 1 mm. This correction is ignored for most leveling. The effect of refraction of the line of sight is to bend it towards the Earth.

This is also ignored in most leveling. Whatever sight lengths are used, the effects of curvature and refraction will cancel if the sight lengths are equal. How to Reduce the Chance of Errors Occurring Leveling should always start and finish at bench marks so that enclosures can be detected. When only one bench mark is available, leveling lines must be run in loops starting and finishing at the name bench mark Where possible, all sights lengths should be below 50 m. The staff must be held vertically by suitable use of a circular bubble or by rocking the staff and noting the minimum reading.

BBS and FSP lengths should be kept equal for each instrument position. For engineering applications, many intermediate sights may be taken from each set- up - under these circumstances it is important that the level has no more than a small collimation error. For automatic and tilting levels, staff readings should be booked immediately after they are observed. Use a digital level where possible as it sakes staff readings automatically The rise and fall method of reduction should be used when weighting reference or control points and the HIP method should be used when setting out.

Other leveling methods Inverted leveling This is a leveling technique that is used to obtain the heights of points above the line of sight such as ceilings and undersides of bridges. To obtain these, the staff is held upside down in an inverted position with its base on the elevated points. An inverted staff reading is booked in a level table procedure is followed taking into account the minus sign. Never use an inverted staff eating as a change point because it is difficult to keep the staff in the same place for more than one reading.

Exam Question: Supplement 2006 SQ A client has asked for an as-constructed drawing of a recently built industrial building. As part of the survey the following series of levels are taken. Prepare a report for the client showing the reduced levels of the manhole inverts and the calculated gradients on the sewer lines, and the soft levels on the building gutters. Example 2 Lets repeat the reduced levels part of the previous exam question assuming we were asked to use the rise and fall method instead