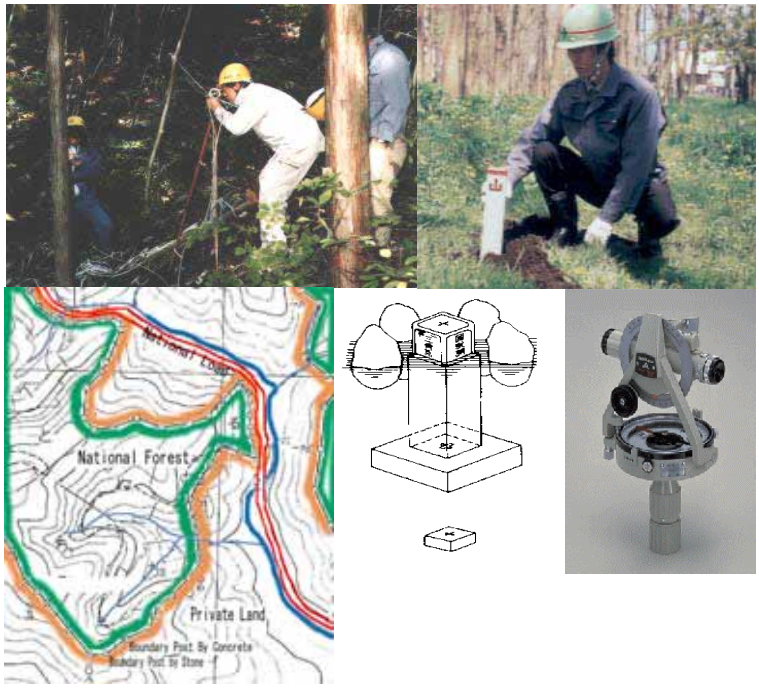
Japan International Cooperation Agency (JICA)

Department for Forestry Development (DFD),
Ministry of Agriculture and Rural Development (MARD),
Socialist Republic of Viet Nam

TECHNICAL MANUAL
ON
BOUNDARY MAINTENANCE FOR FORESTRY ENTERPRISES

Technical Manual Series on the Feasibility Study on the Forest Management Plan in the Central Highland in Socialist Republic of Viet Nam



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Pasco Corporation

Foreword

This manual has been prepared as a part of the “Feasibility Study on the Forest Management Plan in the Central Highlands in the Socialist Republic of Vietnam” as part of JICA’s technical cooperation with Vietnam. This “Development Study Cooperation” has been conducted with the intention of establishing sustainable forestry management for the Kon Plong District, Kon tum Province by preparing a forestry management plan. The common understanding has been that the forest management plan should be prepared to realize sustainable management under fully controlled ownership (utilization rights and control and management rights) of the units of forests, which are to be assigned and secured its use in perpetuity. It is therefore necessary to clearly indicate on the ground as well as on the relevant maps the extent of the forest under management rights, namely, the extent of the forest owned by the Forest Management Unit.

This manual is prepared to the technical stuff of the Forest Enterprises in Vietnam by describing the methods for the installation of boundary markers and methods for the maintenance and management of the management territory. This manual is described taking into the usage for Mang La Forest Enterprise. The articles in this manual are written with reference to the regulations and technical manuals on boundary management of Japanese National Forest Management Agency.

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1. Objectives of this manual

Forest boundaries are normally clearly established not only on maps but also on the actual ground. As the land and forest on either side of boundaries may have different characteristics, it is necessary to distinguish them clearly for the purpose of management and control, as well as to inform forest managers and third parties of the presence of the boundaries. In general, the land ownership boundary is the most conspicuous boundary, not only to prevent owners of adjoining forest lands from inadvertently or deliberately entering the forests of other owners, but also to provide a legal basis for the resolution of disputes between owners regarding the utilization of the forests.

The work of determining boundaries includes a series of operations and procedures such as the survey of the boundaries by qualified surveyors, the installation of ground markers, the representation of boundaries on maps, and registration at land registration offices, along with the preparation of documents indicating agreements between the owners of adjoining forests. Needless to say, a record book that clearly indicates the drawings and locations related to ground markers should be incorporated as one of the means of substantiating the boundaries.

In actual forests, however, a forest area owned by one person may range in size from a few hectares to as much as several thousand hectares. As the boundary can be long and difficult to access, it is not so easy to survey the whole length of boundaries and to set up all of the desired ground markers along them.

In Vietnam, in particular, where all the land belongs to the nation and leasing and registration of ownership is very limited, establishment of land use rights is only available through allocation. Although it is said that the right to use land is conveyed for a long period, it is not clear yet whether such a right is given in perpetuity. It is also not clear whether it is permissible to substantiate boundaries by installing boundary markers.

The objective of the manual is to make it possible to differentiate forests from lands allocated for other uses or to other groups, national enterprises, private enterprises, other legal authorities, or private persons. And decrease that the forests, woodlands and accompanying lands presently provided to Forest Enterprises under their jurisdiction to

control and manage for a considerable period of time.

Differentiation is made by clearly indicating boundaries on maps and on the ground and by providing technical guidance on maintenance and management by separating them from the forests and lands of the other business operations of the Forest Enterprises.

The manual does not cover the methods and standards of forest classification according to the objective of forest control and management, but only describes the means of indicating on the ground as accurately as possible the extent of the forest specifically designated Laws and regulations to the management unit.

However, it shows how to effectively establish the marker points of the boundary indication, and how to install, maintain and manage these marker points on the ground. Therefore, the decision as to where the boundaries or boundary marks are to be established is a matter to be determined and implemented by the Provincial or District Government within the scope of their budget.

2. What are boundary to be maintained

2.1 Nature of the boundaries

Boundaries are the basis for landowners to avoid conflicts with their neighbors over the utilization of their land or to provide proof against claims for third parties that the lands are theirs. Naturally, the boundary indication does not mean anything unless it is accompanied by such drawn representations as topographical maps as well as documentation to clarify the location of the boundary markers. It is readily recognized that a landowner's right to use land is established up to the boundaries.

Even with traditional forms of ownership, it is normally mutually understood that a boundary extends from a certain hilltop to a certain valley or up to a certain pine tree on the ridge. Conflicts over land utilization normally occur when a conceptual boundary drawn on the map has not been clearly marked on the ground. It is not always easy to identify the actual boundaries on the ground using a map drawn on a scale of 1 by 50,000. When a strictly protected area is on one side of a boundary and a product area is on the other side, and the boundary is drawn on a mountainside, markers on the ground are essential to indicate clearly where the boundary is located in order to prevent illegal cutting.

The conceivable types of boundaries to be established are as follows for forest management in the case of the Mang La Forest Enterprise.

(1) Outer boundary of the management areas of the Forest (Enterprise Jurisdiction）.
(2) Administrative boundary (Provinces, Districts, Communes, Villages).
(3) Block boundary.
(4) Compartment boundary.
(5) Sub-compartment boundary.
(6) Land use plan by the Peoples Committee (outer boundary for agriculture land development).
(7) Protection forest and production forest area boundary.
(8) Categorized protection forests Boundary of (watershed, soil protection, strictly protected area, less strictly protected forest, etc.)
(9) Forest operation unit boundary.

(10) Yearly logging sights boundary.
(11) Man-made forests area boundary (species, age, etc.).
(12) Allocated farmlands for villagers.
(13) Contracted farm land and/or agro-forestry land boundary.
(14) Land of Public Assess such as national roads, schools, electric lines, so on.
(15) Land for Housing and home-garden
(16) Others

The forest area under the jurisdiction of the Forest Enterprise includes areas where legally prohibited its utilization of forest products. And the FEs areas are divided into several units of parts where planned different for forest operations. However, the actually land utilization (including those lands whose use is approved, occupied, and traditional) is overlapping across the land between FE and users in traditional manner, and their appealing boundaries. Indication of the actual land use conditions of such overlapping on topographical maps (Forest management plan maps) and ordering these complication are also the long term objectives of boundary management. In order to prevent the expansion of land utilization that is unsuitable or unexpected to meet to the purpose of forest management setting the boundary posts is one of the effective tool.

Even though the land utilization may not be in line with the actual management purpose of land, it is difficult to return the land, and to recover its original land by relocation of the land users in force. It is desirable to proceed with approval for continued land utilization by inhabitants that have traditional use, even though this is necessary significant time flame. Even when relocation of the inhabitants becomes necessary in order to protect the natural environment, sincerely negotiations are expected to rehabilitate to the proper land utilization.

The fixing of boundaries and establishment of markers should given first priority to implement in the areas prone to the place where existing anxiousness to realize conflicts. It is necessary to set the landmarks to the third party or surrounded inhabitants to indicate boundaries in a form that can be easily perceived. It is important that forest management bodies make clear message to decree the land ownership, and to make recognition that the limitation of right or extents of the inhabitant power on land use by them.

2.2 Purpose of the indication of boundaries

Boundaries are normally indicated on Forest Management Plan Maps. There are three reasons for establishing the boundary posts indicated on these maps to the actual ground.

(1) To indicate clearly who or what organization is responsible for forest management, and assure the legal right to prevention or to recover the land from encroachment.
(2) To inform the land management purpose and to discourage unlawful activities.
(3) To prevent operations outside of the planned area caused on misunderstanding.

Installation of markers along all the boundaries indicating forest areas in the previous section is actually almost impossible and also not necessary. In normal practice, in areas liable to encroachment, whether this is accidental or incidental, permanent markers (stone markers) are installed and measures should be taken to keep strictly the survey records so that the stone markers can be restored if they are destroyed. However, in areas where stay deep into the jurisdiction of a forest management body, and clear the areas legally belong to the management body (i.e. the courts), and therefore, easily recovered, simple forms of indication (Notice boards, painted markers on tree trunks) will be sufficient.

Even on the surrounded to the outskirts areas of the management forest, if the boundary is located on an obvious natural river, stream or mountain ridge no farm boundary post may needed. And as the areas located so deep inside a protected area, no intrusion or conflict can be expected or in the cases of encroachment, to recover the land is rather easy, then there is little need to install stone markers also.

With boundaries established for their convenience in forestry management purposes as indicated in (3) and (4) of the previous section, the indication should be established on the ground to clarify the area of the forest to avoid errors in the forestry operations. The extent of forest blocks are specified by providing forest block border marks on trees or rocks along the roads or footpaths.

Item (9) of the preceding section covers the types of boundaries that are reviewed every time the forest management plans are re-examined. In actual practice, operational areas are specified in accordance with the annual plan. And the operators appointed by the persons responsible for forest management as contractors or villagers with practical

experience, are responsible to account for any damage due to their own errors occurring in the area or outside of the specified areas. Therefore, there is no area where conflict should occur that cannot be restored. Such boundaries are sufficient only by indicating on maps.

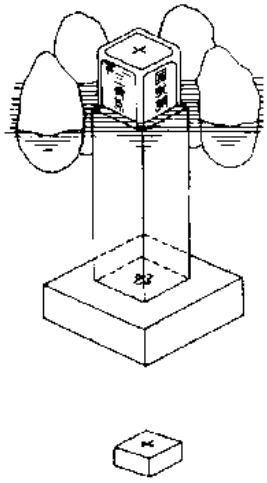


Figure- 1 permanent land mark

Regarding item (10) of the preceding section, the site of the operation can be conveyed to the operator by marking the surrounding trees each time. Regarding item (11), as the boundary automatically becomes clear a few years after afforestation, provisional marking is sufficient to serve the purpose.

Regarding items (12), (13), and (15), it is rather difficult to state that there is no possibility of encroachment. Permanent markers should be installed to the extent that this is possible. The degree to which encroachment or expansion of encroachment is likely determines how deep the permanent markers should be buried, which also depends very much upon the past level of cooperation of the inhabitants in the area with the forest manager. The manager should establish amicable relations through the day to day implementation of the support plan for inhabitants so that a simple means of indicating boundaries should be sufficient to maintain good relations.

When approval is given for certain land utilization, it is necessary to maintain documentary records that are stocking survey data of relative position. These data is a basis to recover the boundary line and posts if the third parties expanded their land use exceeded the boundary to the Forest management body's jurisdiction.

Regarding item (14), the general practice is that public authority users are obliged to install boundary markers on the ground.

The Vietnamese laws and regulations requires clearly show the boundaries on maps and/or ground in the following cases.

Land Marks for forest categorization	
02-CP 1994	
Article 13	Maps of scale 1/5,000 to 1/25,000 for forestlands, which has been assigned. On the maps, the land marks for boundary of land area

	should be pointed:
58-/HDNN8 1991	
ARTICLE 21	In the forest and mountainous region, based on the forestry planning, the district P.C. will create the boundary and instruct the people to conduct fix, intensive and enrolling cultivation, husbandry grazing, agroforestry aquaculture.
17-HDBT	
Article 5-1):	Ministry of Forestry determine forest categories; delineate boundaries of forest and forest plantation lands on maps scaled at 1/10,000 and in the field down to the commune level;
300 CV/RD 1993	
B-1.1.	Define project borders:- Borders are to be marked on the map and in the field (a land allocation for 327 project border)
Regulation 99	
Article 5:	The boundaries of special use forests, protection forests, production forests must be clearly defined on maps and in field with a guiding milestone system and controlling statistic filing.

The Land Law specifies that the boundaries of the areas designated as forests in the national land utilization plan must be clearly indicated as such in topographical maps. (Article 13 02-CP 1994) The land markers indicating the boundaries must be expressed in relation to a base point that can be read from topographical drawings. The forestry law specifies that the boundaries of forest areas that also form the boundary lines of land utilization are to be determined by the People's Committees (Article 21 58-HDNN8 1991). Categorical boundaries of protection forests, special use forests and production forests are determined by MARD and should be indicated on topographical drawings, and their contents should be publicly available to the Commune level (Article 5-1 17 HTBT 1992). An instruction order made in 1999 specifies that boundary markers should be installed on the ground (Article 5 Regulation 99).

Afforestation plans utilizing national funds are required to show the boundaries of the project areas not only on maps, but also on the ground (300 CV/RD 1993).

2.3 Boundary indication methods

There are a variety of methods available to indicate boundaries on the ground according to the extent to which it is necessary to maintain them. Solid stone markers are normally used to indicate base points in surveys or for re-surveying (base points for national

surveys such as triangulation points and benchmarks). These are then used as points on the Outer boundary of Forest Enterprises where conflicts with adjoining land owners tend to occur as well as for the boundary of strictly protected areas.

Stone markers with the configuration shown in Figure 2 are used for important points. The figure shows the stone markers used to indicate the triangulation point. These stone markers are used to establish the base points of surveys and are installed at specific points in a designated geographical area where they cannot easily be damaged or moved due to natural hazards or human error. Permanent marks can also be engraved on natural rocks as shown in Figure-3.

Figure-2 A typical sample of milestone for important points of boundary (triangulation points and benchmarks).

As it is important for the markers to be installed at ground points that will never shift. Marks should not therefore be made on the trunks of large trees that could be illegally cut down.

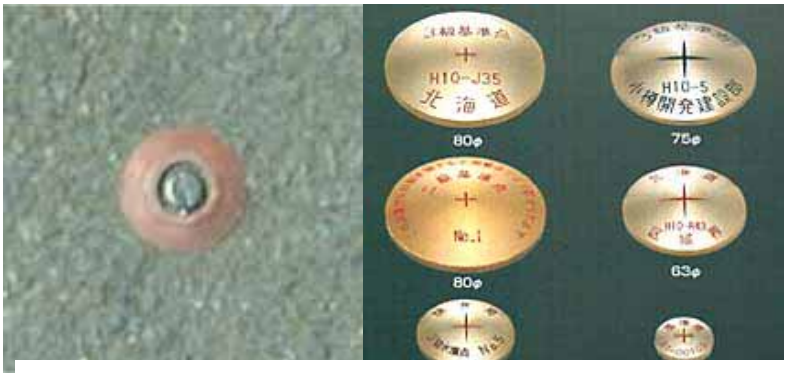


Figure-3 Samples of mile stone on concrete floor or rock

Stone or concrete markers will be buried on the Forest Enterprise areas or especially important points along the boundary of protected areas. The configuration should be a rectangular 8 x 10 cm post, marked with a point number, the name of the boundary (for example

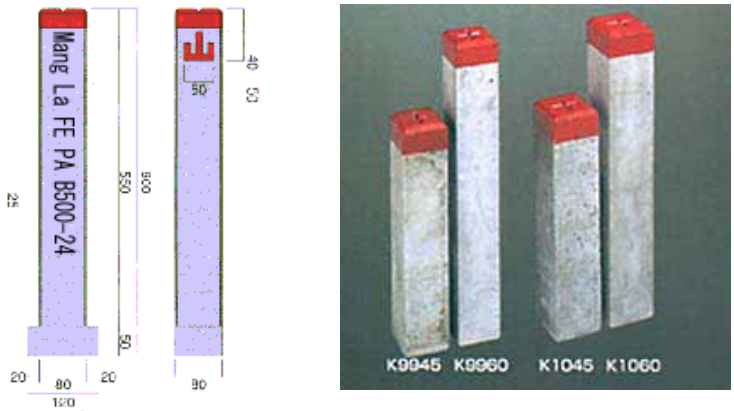


Figure-4 Sample of concrete post

Mang La FE) and generally painted red at the top so as to be easily recognized (Figur-4).

Figure-5 Sample of simple boundary point and guide post

In principle, such sturdy permanent markers should be installed on the periphery of the Forest Enterprise area as well as that of protected areas. In practice, however, it is not possible to establish them exactly according to this principle due to access and other problems. Where boundaries overlap with the lines of clear geographical features (such as mountain ridges or rivers) or at the points where the boundary lines obviously start or end, markers can be omitted.

Where there are access and other problems, it is normal practice for trees closely following the boundary to be used to indicate the boundary. A series of trees selected at intervals in such a way that they can be seen from each other's location are marked with red paint to indicate the boundary. Boundary markers are then installed for every few trees marked with paint (Figure-5).

Figure-6 Sample of block boundary board

The various boundaries determined according to the forest management plan are described on a large scale topographical map (generally 1/5,000-1/10,000 for forest management) so that forestry engineers can determine the location. However, as not all the people involved in forestry work are familiar with topographical maps, it is desirable that important boundaries should be indicated on the ground as well so that local inhabitants and contractors can follow them.

The most important of these boundaries are the Block boundaries. Ridgelines, rivers and other conspicuous natural features are established as the boundary for a Block. However, in reality, due to the uninterrupted expanses of very similar mountain ridges or the absence of viewpoints for observing ridges, the chances of recognition errors occurs

rather often. It is therefore recommended that Block Boundary Boards be installed at points where important roads or pathways intersect with the Block boundaries. Small markers (Figure-6) with the corresponding Block number should be attached to trees along the road to the right or left side of the Block Boundary Board.

Boundary lines to be considered next are the periphery lines along the Contractual works areas related to the villager support program and the 5 million afforestation plan Projects. As these periphery lines are required for identifying the extent of long term land utilization rights, concrete markers should be installed. However, on the cases of conflicts over land utilization are rather low, since it is the Forest Enterprise that is in the position of placing the order for the contract. As the requirement for the accuracy of the boundaries is not so strict, it is practical to deal with the situation by installing a few boundary made by plastic posts at several base points together with Notice Boards (Figure-7) indicating the positions of the plastic posts.

Figure-7 Sample of a Notice Board

3. Boundaries be maintained by Forest Enterprises

Forest Enterprises have to maintain various boundaries for the control and management of the forests. Technical guidance is provided here for surveying and boundary point installation and maintenance, in order to establish boundaries on maps and on the ground for the peripheries of the most important areas of jurisdiction and protection where land utilization conflicts tend to occur.

3.1 Selection of the boundary survey points

It is necessary for the boundary lines (as indicated on topographical maps) to be reproduced as accurately as possible on the ground. The positions of the respective survey points are normally determined in the presence of local people who have rights to use the forests. Survey points should be selected by considering the following locational factors.

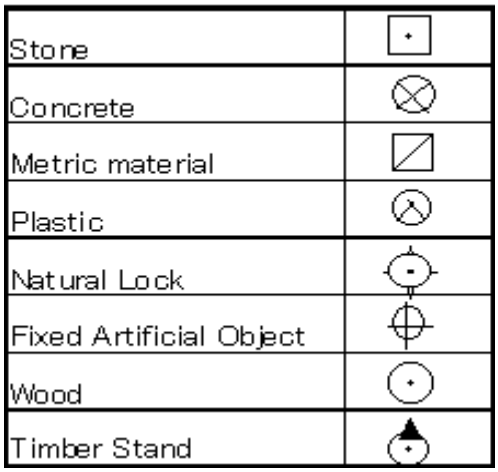


Figure-8 Delineate sample for boundary post on management

a. Points along the boundary where it changes direction (both horizontal and vertical redirection)
b. The nearest boundary points to a conspicuous topographical or natural feature (mountain tops, river confluence points and road crossings for example)
c. Points that can be seen directly from adjacent points
d. Points that are unlikely to be lost due to natural hazards (when the boundary follows a riverbed, it is necessary for auxiliary survey points that are not subject to flooding to be identified in the area so that the survey point coordinates can be re-established by calculation using standard methods.)
e. Work efficiency (the longer the distance between survey points is rather efficient to setup there boundary posts may be, but restoration may be more difficult if the marker posts are lost.

3.2 Types of marker posts and displays

Granite is the most common material for boundary posts, but concrete posts can be used if granite is not available. When the distance between the posts is long, it is desirable to install plastic auxiliary posts in between them, considering the advantages for future inspections and possible restoration. Mark on topographical maps the types of posts used. Figure 8 shows for examples of indicators used in Japan.

Figure-9 Sample of Index Board for Boundary Post

3.3 Boundary post indication

As the surface area of posts is not particularly large, they tend to disappear in grass or bushes a few years after installation. Markers may be installed nearby to help find the boundary post. It is desirable to install an index board painted in conspicuous colors above the height of grass near major points where the boundary changes direction or at the base points, in order to facilitate later inspection.

4. Surveying (Compass surveys)

The establishment of the boundary line on the ground is referred to as “boundary fixing”. The boundary fixing work starts with a survey. The boundary itself is already determined on the map and customarily on the ground. The process of replicating the abstract representation of the boundary on the map onto the ground itself is as follows.

When an accurate survey is to be conducted, the transit survey is usually conducted. In certain countries the transit survey is obligated for the positioning for the public survey. However, as the practical means for speeding up of the actual work, it has been assumed that the compass survey is to be carried out. The procedure is described as follows.

4.1 Basics of the compass survey

The compass survey is generally used for forest surveys. This is because a compass is easy to carry, easy to operate, and handy for surveying in forest areas where the land features are changeable. However, the level of care and understanding of the operator affect the accuracy of the compass survey quite substantially. Therefore, it is important for compass survey operators to properly understand the advantages, disadvantages, and the limits to surveying accuracy and also to fully understand the methods for correct operation.

(1) Advantages and disadvantages of the compass survey

The advantages have been described earlier, but the following points regarding this type of survey should be followed carefully.

a. The magnetic needle, which is the vital element of the device, is sensitive to various sources of magnetism.

b. As the device is simple in structure, it is not suitable for measurements requiring a high degree of accuracy.

c. Since the installation and operation (observation) of the device is so simple, it may be used without due care, resulting in reduced accuracy of the measurement.

d. Since the measurement accuracy is low, the device is not suitable for surveys in which extrapolation of distance measurements is too great, and is also not suitable for the measurement of large areas.

(2) Accuracy of the compass survey

As mentioned earlier, the accuracy of the survey measurement is greatly affected by the attentiveness of the operator. The general level of accuracy for survey measurements is expected to be between 1/200 – 1/300. However, as the surveys are conducted in forest areas where the variation in terrain is rather extensive, an accuracy of 1/100 is generally accepted.

(3) Real North and Magnetic North - Magnetic Needle Deviation

The Real North, Magnetic North and Magnetic Needle Deviation are as shown in Figure-10. The magnetic needle declination for the actual survey location must be checked beforehand. Measurement results must be corrected accordingly.

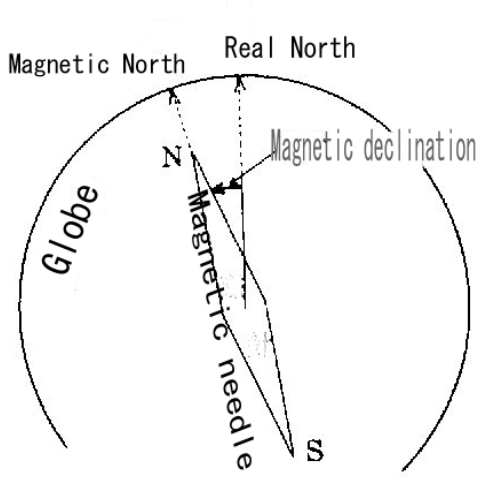


Figure-10 Real north and magnetic north

(4) 360 degrees azimuth

Survey compasses available on the market are of the 360-degree azimuth type that measures the azimuth degrees from due North. (the standard vertical axis of topographical drawings)

4.2 Outline of the work procedure

The procedure for compass survey work is as follows (Figure -11).

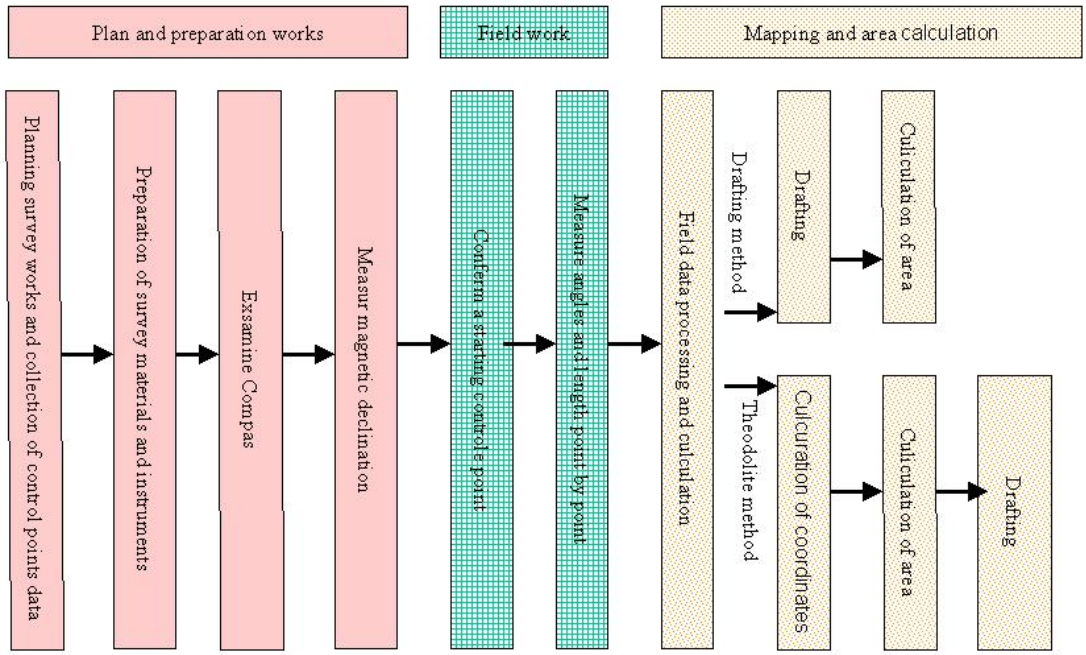


Figure-11 Process of Compass Survey

4.3 Planning and preparation work

(1) Survey plan and checking of the known points

The coordinates of the triangulation points and other base point data indicated on existing topographical maps are compiled and marked on the survey map and aerial photographs. It is necessary for the boundary point survey to define clearly where on the ground surface the survey points are located. For this purpose, the starting point, intermediate points and end point must be connected with other existing points. By connecting them with these base points, errors in locating the survey points can be corrected. The following must be kept in mind when selecting an existing point as the survey starting point.

a. When known points such as base triangulation points or boundary points (of boundaries already surveyed) have been established near the area to be

surveyed, select these as the base points.

b. When high accuracy is not important, conspicuous topographical features, such as valley convergence points that are clearly indicated on topographical maps, should be selected as base points. In this case the coordinates should be read from the map. When a drawing is prepared using cartography, a map of the scale 1/10,000 or larger is recommended to make it is easier to identify known concordant points in preparing a drawing using the same scale.

(2) Materials and instruments to be prepared

Followings are materials and instruments used in compass survey.

a. Compass and tripod
b. Survey poles
c. Tape measure or survey rope
d. Steel tape (2 m)
e. Survey note book
f. Skew distance conversion table
g. Portable drawing board (circular protractor)
h. Basic map and aerial photograph

(3) Structure of the compass

Figure-12 shows the structure of the compass.

(4) Inspection and adjustment of the compass

As the compass is of simple structure and the required accuracy of the survey is not so high, the checking of measurements tends to be treated lightly. However, as measurement errors (constant errors) are compounded in subsequent measurements unless they are corrected, they can substantially affect the final accuracy of the survey. Inspection and adjustment of the compass before conducting the survey is essential and should never be neglected.

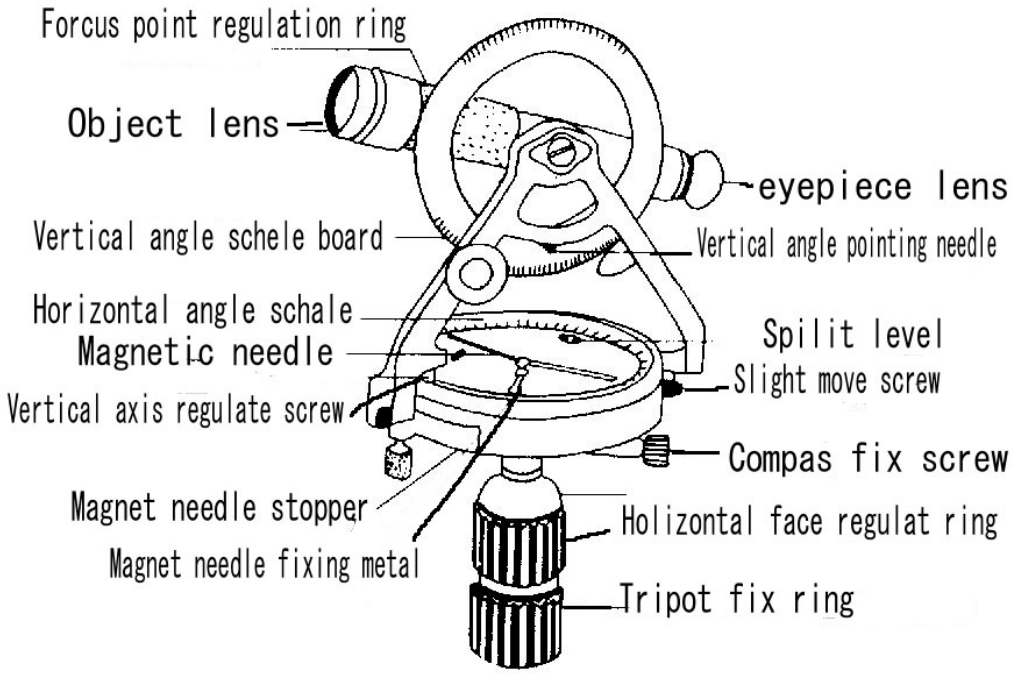


Figure-12 Structure of a Compass

a. Adjustment of the spirit level (air bubble tube) --- inspection of the vertical axis and level axis

As the sensitivity of the bubble tube of the compass spirit level is limited, adjustment is seldom required. It is normally attached to the device and even comes with an adjustment mechanism. Compasses used for many years must be inspected in the following manner and factors that may affect the azimuth must be adjusted or repaired.

a) Set the compass horizontally by bringing the bubble of the tube to the center.
b) Swivel the compass 180 degrees to check whether the bubble stays at the center. If the bubble still moves, adjust it at the halfway point of the distance it moves using the adjusting device.
c) Repeat this procedure several times to complete the adjustment.

b. Inspection of the sensitivity of the magnetic needle

a) Set the device horizontally.
b) Read the scale as indicated by the needle. (The reading unit should be 10', 1 degree on the scale should be divided into sixths visually).

c) Then move the needle by carefully bringing a piece of iron close to the compass and then taking it away. Check that the needle returns to its original position (the azimuth read by b).
d) Repeat the procedure in c) several times. If the needle returns to its original position from any position it moved to, the sensitivity of the needle is sufficient. If it does not return to the original position, the tip of the needle shaft has become worn or the magnetism of the needle has become weak. Necessary repairs must be carried out.

c. Inspection of the horizontal swivel motion of the needle

a) Set the device horizontally, turn the device carefully after the needle has stopped completely. Check that the horizontal scale disk and both ends of the magnetic needle turn at the same height in any position.
b) If they do not turn horizontally, make an adjustment by moving the brass wire wound around the needle.

d. Eccentricity of the needle support pivot

a) Set the compass horizontally and read the scale indicated by both ends of the needle. Calculate the difference between the south and north needle point reading. (it should be 180 degrees)
b) Turn the compass 90 degrees and calculate the difference in the needle position reading in the same manner.
c) When the south and north end readings in a) and b) are the same, the pivot position is correct.
d) If the readings taken according to c) differ, the pivot is eccentric and must be adjusted before the compass is used.

e. Inspection of the vertical and horizontal axes

Many compasses can be folded up for easy transportation in a case. This sometimes alters the accuracy of the 90-degree arrangement of the vertical and horizontal axes. This point should occasionally be checked.

a) Hang a ball close to the ground from a tree at a height of 3 m or more
b) Install the compass at a position about 3 m from the ball (focussing distance of

the telescope)

c) Look at the upper part of the hanging string through the telescope (angle of elevation 40 degrees or more). Move the telescopic sight so that the cross hair vertical line coincides with the string, and then fix the device by turning the setting screw.

d) Then swivel the telescope downward slowly using the fine adjustment screw. If the cross hair vertical line that indicates the center of the telescopic sight shifts away from the hanging string, adjust it by turning the horizontal axis adjustment screw.

f. Measurement of the magnetic needle declination

As measurement using the compass always coincides with the magnetic needle declination, the declination must be measured in the following manner before the survey is conducted. Select two or more continuous fixed marker points of stone or concrete on a boundary for which the results of the boundary survey are known. Calculate the difference between the azimuth indicated in the boundary book or coordinate calculation book and the magnetic needle angle, and determine the magnetic needle declination from the average of the difference. Generally speaking, the magnetic needle declination includes ① the difference due to latitude; ② local differences ③ daily cyclical variations ④ long-term cyclical variations ⑤ and changes due to magnetic storms.

4.4 Surveying

The survey work is to be carried out as follows.

(1) Identify at the site clearly known points at coordinate positions on the ground surface (points that can be used as reference points) as the survey base points.

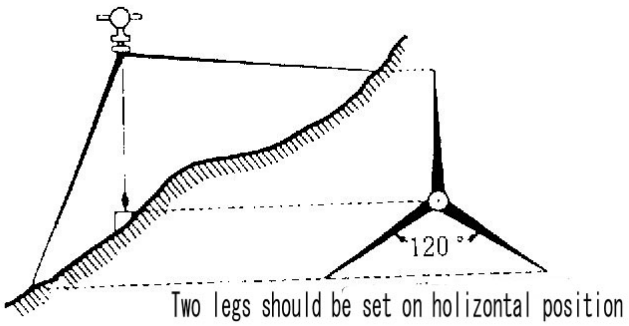


Figure-13 Compass setting method

(2) Survey

a. Precautions to be taken when the device is installed

a) Be sure to use the tripod.
b) The height of the device should be such that the graduation disk can be easily set.
c) Suspend the plummet above the survey post to center the device.
d) Irrespective of the steepness of the slope, when the device is set as shown in figure 14, the centering can be made easily and speedily with stability. (Two legs of the tripod are to be set on the lower side of the slope while one leg is set on the higher side)

b. How to set the pole

The person who holds the pole should squarely face the compass, stand erect, and hold the pole lightly using both hands, with the pole held vertically in the middle of the body and the bottom of the pole placed midway between both feet.

c. Collimating position

When the pole is collimated, the collimating position must be determined as it is related to the distance measuring position. Normally the following method is used.

a) Attach a conspicuous item such as a handkerchief to the pole at a fixed height, and collimate the tie knot (set at the cross line in Figure-14A)
b) When the survey post can be collimated, collimate it using the bottom tip of the pole. Fig-14B).

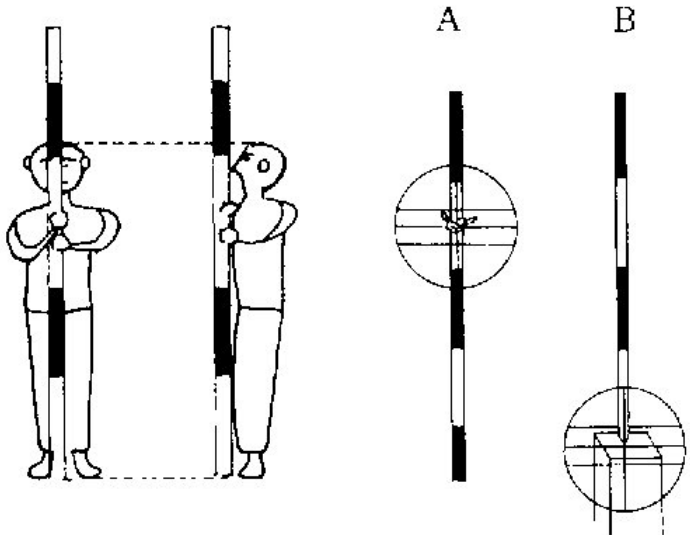


Figure-14 Pointing pole setting method

d. Reading of the magnetic needle azimuth

a) Take the reading after the needle has completely stabilized.
b) When the magnetic needle azimuth is determined, the observer's eye should be positioned square to the magnetic needle.
c) Subdivide the 1-degree scale when reading. (When the needle is at the middle of the scale point, the reading should be 30 minutes. When it is a little left or right from the center read 20 minutes or 40 minutes.)

e. Reading of the vertical angle

a) Face square to the vertical scale disk, and read the angle indicated by the vertical-pointing needle.
b) When the slope is steep, the reading should be conducted accurately as a reading error of a vertical angle greatly affects the horizontal distance. (If a vertical angle of 40 degrees is erroneously read as 41 degrees, the reading error of 1 degree over a slope distance of 50 m will result in an error in the horizontal direction of 56 cm.)

f. Distance measurement

Stilon or Eslon tape made of materials with minimum expansion or shrinkage is used for measuring the distance.

a) When a handkerchief knot is collimated, the distance from this point to the center of the telescope is measured as the skew distance.
b) When the head of a post is to be collimated, the distance from the center of the post to the center of the telescope is measured to determine the skew distance.

g. Magnet needle azimuth observation

In principle the observation of the magnetic azimuth should be conducted using foresight and backsight as follows:

a) This makes it possible to discover and eliminate local gravitation.
b) Reading or entering of errors can be detected immediately.
c) As the mean value can be calculated, the accuracy can be enhanced.

h. Method of entering data in the field book and precautions regarding the entries

a) Entry should be made at the time of each observation.
b) Foresight and backsight reading values should be checked for errors.
c) Enter the actual situation of the observation points and the area around the survey line in the remarks column and sketches.
d) Indicate clearly the magnetic needle declination.
e) An error in writing must be corrected using crossout lines; never use an eraser.

(3) General precautions for the survey

a. Pay attention to local gravitation. As observation using foresight only is unable to detect local gravitation, pay extra attention when the survey is conducted in an area of geological magnetism, in the vicinity of power transmission lines, and in areas where steel material such as a steel tower is present. Be sure to carry out the foresight and backsight observation.

b. When the magnetic needle is not in use, push the needle up using the needle holding screw to avoid wear of the tip of the needle shaft.

c. Ensure that nearby tools cannot affect the magnetism of the compass.

d. Use the same compass for the survey of a single area. If the compass has to be replaced for any reason, the difference in the magnetic declination (device difference) must be corrected in later arrangement.

e. The survey of boundary points that require site management must be conducted after the survey posts have been installed.

(4) Method for eliminating local gravitation

Foresight and backsight are reverse azimuth related. Accordingly, if no survey error is present, their difference should be 180 degrees. See below table-1. On the sample, 3-4 (237-57=180) is 180, but 1-2 (244-69=175) is not 180. When the difference is not 180 degrees, local gravitation must be present. It is clear that the survey point 3 for the foresight observation 3-4 and the survey point 4 of the

backsight observation 3-4 are not affected by local gravitation. Accordingly, the observation values 320 degrees and 237 degrees of the point 3, and 57 degrees and 296 degrees of the point 4 are correct. Therefore, the foresight of 2-3 320 degrees, a reverse azimuth of 140 degrees and the backsight of 4-1 296 degrees, reverse azimuth of 116 degrees are correct. The local gravitation at the point 1 has been declinated by 296 degrees – (120 degrees + 180 degrees) = -4 degrees, while the foresight of 1-2 is 65 degrees – 4 degrees = 65 degrees and the back sight of 1-2 is 65 degrees, a reverse azimuth of 245 degrees.

Table- 1 Sample table to adjust horizontal angles by micro gravitation effects of magnetic needle

Survey line	Fore see	Back see	Adjusted angle		Harmonized fore see	Harmonized back see
			Fore	Back		
1-2	69	244	-4	+1	65	245
2-3	139	320	+1	0	140	320
3-4	237	57	0	0	237	57
4-1	296	120	0	-4	296	116

(5) Survey method

Although a variety of surveying methods can be used, the description given here is the most widely employed advanced method in which the block errors can be acquired. (Fig 6).

a. Place the compass at the survey point 1; collimate the survey point 5 (backsight) to measure azimuth 111 deg. 50 min. Then, collimate the

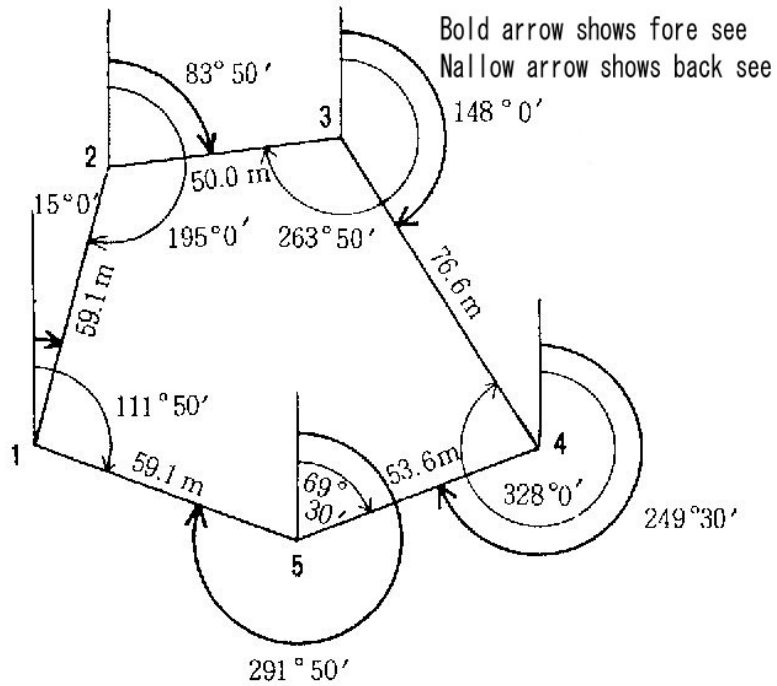


Figure-15 Survey on Progression Method

survey point 2 (foresight) to measure the azimuth 15 deg. 0 min., for the vertical angle and distance.

b. Move the compass to the survey point 2, conduct the operation according to a, and continue with the subsequent operations one after the other as illustrated in figur-15.

c. Table 2 indicates the form of the survey field book

Table-2 Sample form of Compass survey field note

		Horizontal Angle						Vertical angle						Distance		Remarks
Survey point	Sight point	Fore sight		Buck sight		Average		Fore sight		Buck sight		Average		Slope length	Horizontal length	
		°	′	°	′	°	′	°	′	°	′	°	′	m	m	

4.5 Preparation of the survey drawing

(1) Survey field book calculations

a. Calculate the mean values of the azimuth and vertical angles.

b. Calculate the horizontal distance and height difference if necessary. (Figure-16)

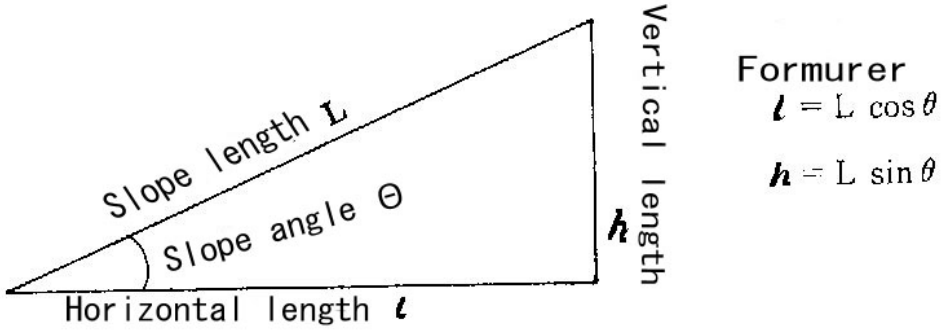


Figure-16 Relation between slope length, vertical and horizontal length

Acquire the horizontal distance and height difference using the “Conversion table on slope length and horizontal length” attached at the end of this document and enter them in the relevant column of the field note table ---. This can be calculated directly using a tabletop calculator with a built in trigonometric calculation function, available cheaply.

(2) Arrangement procedure

Drafting and longitude/latitude methods can be used for drafting and area calculation. Determine which method should be adopted, considering the accuracy requirements of the survey.

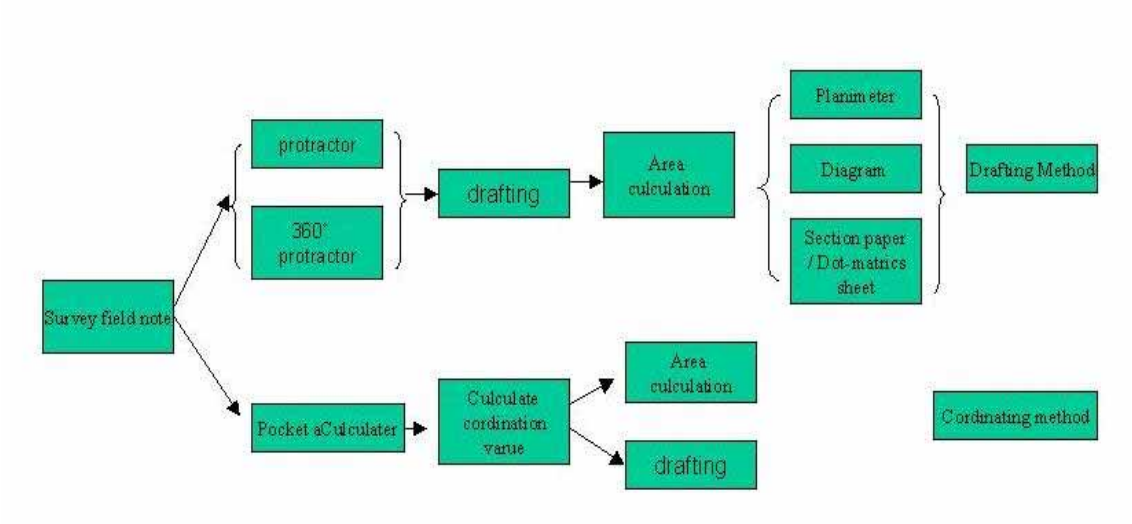


Figure-17 Process and methods for drafting and area calculation

a. The drafting method indicates drafting errors. The differences between first point positioning on the drafting chart and the first point drafted from last point on the drafting chart does not fully indicate survey errors. It is generally considered that a survey in which no survey errors are calculated is no survey at all. Therefore, drafting must be conducted after determining the drafting scale, considering the accuracy of the survey. When the scale of the drawing to be drafted is different from that of the draft to be inserted (basic drawing); the reduction scale should be made the same as that of the drawing to be inserted.

b. The longitude/latitude method is not common in the case of compass survey due to the calculation process is not simple, however, as the method can indicate very accurately the positions on the earth by connecting the base survey points with public survey points (triangulation points, simple base points, and others). It is recommended that the distances of the survey points from the longitude and latitude coordinates be calculated when it is expected that the result will be used for legal purposes such as the survey of boundaries. Table-5 shows a simple calculation method, considering the accuracy of the compass survey.

(3) Drawing methods

1). Method using a protractor

a) Drawing tools to be prepared
   ① Protractor
   ② Hard pencil
   ③ Plotting paper with minimum expansion and shrinkage
   ④ Survey pin
   ⑤ Triangle drafting ruler

b) Determine the survey point 1 on the plotting paper with the upper end of the paper set as the north, while taking the profile of the area to be surveyed into consideration.
c) Place the protractor on the survey point 1, set the azimuth and insert a survey pin on it.
d) Place the ruler at point 1 and the pin and determine the position of point 2.

Repeat this procedure.

2) Precautions when drafting

a) Use survey pins as much as possible when an azimuth is to be determined
b) When a distance is to be measured, attach a drawing rule to the survey pins and visually measure the distance in units of 0.1 m.
c) When the protractor or a rule is used, be sure that the observer's eye is positioned square to the scale.
d) Make sure that the pencil is sharpened in order to draw lines as thin as 0.1 mm.
e) Be sure to identify the azimuth and distance between the survey points of the prepared drawing.
f) Enter the name, azimuth, reduction scale, date of the survey and other important items on the drawing.

3) Drawing closure error

Prepared drawings contain closure errors due to the survey error and drawing error. The total closure error of a compass survey for a plain position is normally 1/10. The error includes the error that occurs during a survey that begins from the starting point and returns to the starting point.

4) Error distribution

When the closure error is within the tolerance, the error is distributed in accordance with the distribution proportion calculated in the following manner.

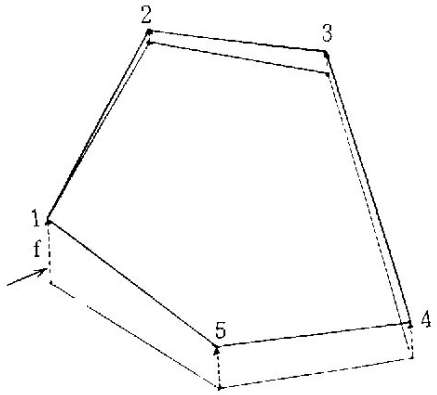


Figure-18 Error distribution method

a. Acquire the total distance between the points (Σ S = 298.40 m)
b. Measure (f・・0.90).
c. Calculate the correction coefficient
(Error distribution amount per 1 m Z = (f/ Σ S = 0.90/298.40 = 0. 00302))
d. Calculate the error distribution amount for each point.
Distribution amount of the point i = $\sum_{i=1}^{i} Si \times Z$
e. Draw from each point lines parallel to f as shown by Figure-17, take the distribution amount as calculated by d and connect each point to draw the corrected drawing.

Table-3 Example for error distribution calculation

Field survey note			Calculation for error distribution	Error
survey point	Fore sight	Horizontal length(m)		
1	2	59.10	(0.95/298.40)*59.10	0.18
2	3	50.00	(0.95/298.40)*(59.10+50.00)	0.33
3	4	76.60	(0.95/298.40)*(59.10+50.00+76.60)	0.56
4	5	53.60	(0.95/298.40)*(59.10+50.00+76.60+53.63)	0.72
5	1	59.10		
	$\sum$ =	298.40	final different length=0.95	

4.6 Area calculation

(1) Methods of area calculation

Methods of area calculation include the planimeter method, the three skew method, the dots print sheet method, and the point grid method.

a. Planimeter method

The planimeter, also called an integrator, includes ones with a simple structure and those with a structure that allows calculation of areas with a high degree of accuracy. They are all of the same basic structure.

b. Three skew method

The three skew method is a method of acquiring the area using the formula “base × height / 2”, and is an effective method when the drawing is made at a substantially large scale (when the number of survey points is large, the work becomes rather complex).

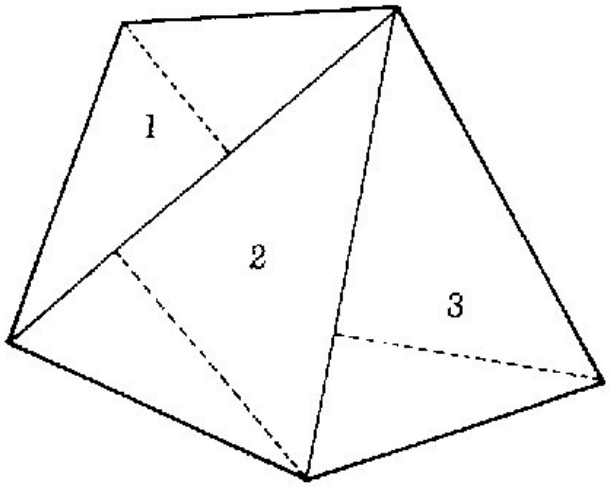


Figure-19 Divide into several triangles and give a number for each triangle

a) Corner points of measure-ment are connected with lines so as to produce several triangles inside. In order to insure that the angles of any of the triangles are not less than 30 degrees. Take note that the subdivided triangles must be of a form that is close to an equilateral triangle, and the base of each triangle must be shared by another triangle as one of its sides. Provide arrangement numbers for these triangles. (Figure-19).
b) Measure the length of the base and the height of each triangle.
c) Calculate the area of each triangle. Sum up all the areas to acquire the total area.

c. Section paper method

a) When survey drawing is prepared on a sheet of section paper using a protractor, count the number of squares in the drawing and multiply the total number of squares with a factor to calculate the area. Squares crossed by the survey lines are counted as 1/2 and are processed statistically.
b) When the survey drawing is not prepared on plotting paper, the drawing should be traced onto transparency section paper with minimum shrinkage for the area calculation.

d. Method using a dot grid paper (referred to as the dot plate method)

Place a dot plate on the survey drawing, count the number of the dots enclosed in the drawing, and calculate the area by multiplying the number of points with a factor. This is a convenient method for calculating the areas of forests, small isolated areas or a large number of sectors.

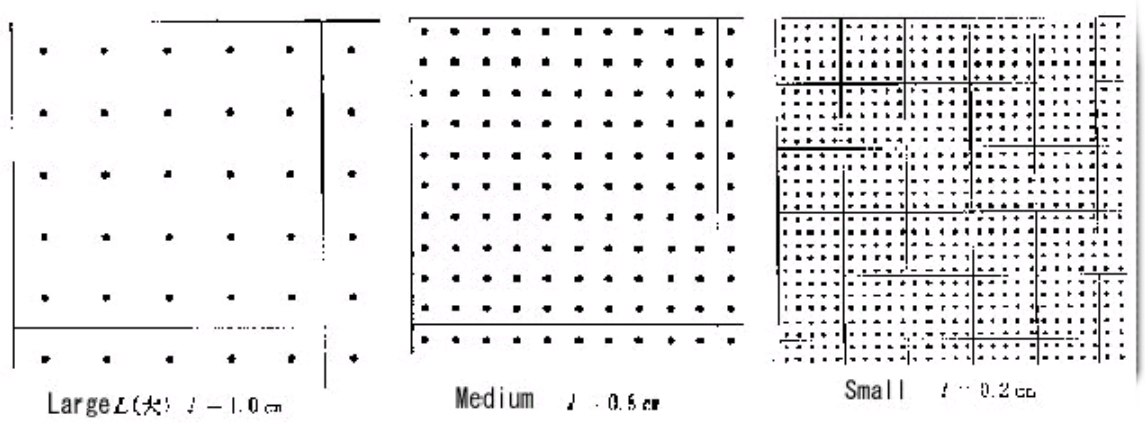


Figure-20 Samples of dots sheet

Three types of dot plates L (large), M (medium) and S (small) are available. One point represents an area as shown in Table 4. The area is to be multiplied by the corresponding value to calculate the total area.

Table 4 Dot plates (L, M ,S) and area for one point represents

Dot Sheet	Length between dots	Area represented by a dot				
		1/1000	1/5000	1/10,000	1/20,000	1/50,000
Large	1.0 cm	0.01 ha	0.25 ha	1.00 ha	4.00 ha	25.00 ha
Mediam	0.5 cm	25.00 ㎡	0.0625 ha	2.50 ha	1.00 ha	6.25 ha
Small	0.2 cm	4.00 ㎡	0.01 ha	0.04 ha	0.16 ha	1.00 ha

How to count the points

First of all, place the dot plate in such a way that the grid roughly faces to the north, and counts the points (A point that sits on a line of the drawing is to be counted as 0.5.) Then, swivel the dot plate roughly 45 degrees (by referring to the manner of placing the dot plate for the first time) to the left, and count the number of dots n in the same manner as that used for the first counting. Then, swivel the plate roughly 45 degrees to the right, count the number of dots for the third time and acquire the arithmetical mean. A calculation that results in an abnormal value is not to be counted.

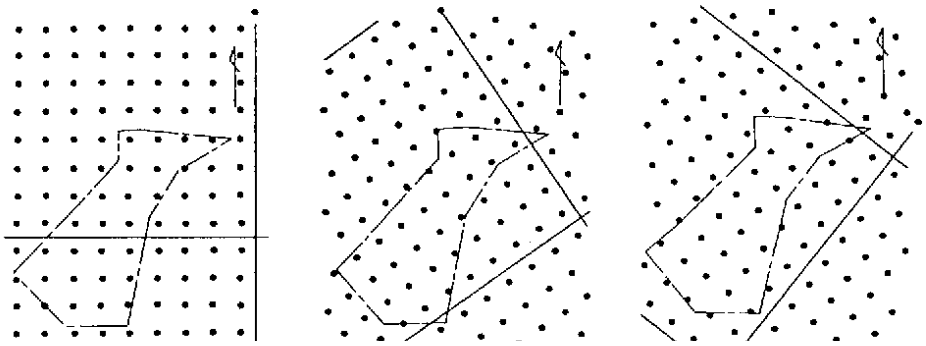


Figure-21 How to use dots sheet for area calculation

(4) Longitude/latitude method

As stated earlier, methods using drawings are accompanied by drawing errors. When the drawing scale is small, the drawing error exceeds the survey error, not allowing for calculation of the survey error. Therefore, it is recommended that the longitude/latitude distance calculation method should be used for the area calculation and measurement drawing preparation as far as possible. This method is described using the calculation system and example shown in Table 5.

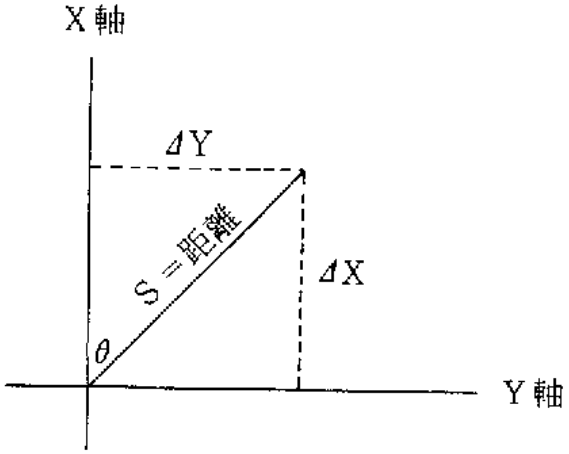
a. Coordinate difference calculation

a) Method using a table calculator in which the triangulation function (sin, cos) has been installed

Coordinate differences are calculated using formulae.

b) Quadrant azimuth

Coordinate differences are calculated after an all-periphery azimuth has been converted into a quadrant azimuth. (Recent calculators make it possible to calculate coordinate difference corresponding to the quadrant azimuth, if an azimuth is entered.) The quadrant azimuth has been described in (1-(5)). There are choices for the all-periphery azimuth as shown in Table --. Refer to figure-22 for the calculation method of the coordinate differences.



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$\Delta Y = S \cdot \sin\theta$

$\Delta X = S \cdot \cos\theta$

b. Area calculation

Use the formula “(Upper base + Lower base) × height / 2” for the area calculation.

c. Drawing

a) Trace the plotted coordinates (normally at 10-cm intervals, depending on the reduction scale of the drawing) accurately on a plotting sheet or polyester base of minimum expansion and shrinkage.
b) Develop the coordinates of the known and the surveyed points.
c) Prepare the survey drawing by connecting each survey point and attaching the survey numbers.
d) Check to confirm that there is no error in the development, by referring to the distance between each of the survey points with the horizontal distances on the survey field note.
e) Enter the survey drawing name, reduction scale, azimuth, the date of the survey and other necessary matters.

5. Boundary mark establishment

After the survey has been completed and the boundary points established, boundary markers should be installed as early as possible to secure the boundary.

5-1 Selection of the type of the boundary markers

In accordance with the importance of the boundary marker, selection should be made from among stone, concrete or plastic markers. If there are sufficient funds, stone markers are recommended for permanent indication. Stone markers are also recommended for locations that are expected to form the starting point of various surveys.

5.2 How to bury markers (stone markers)

a. Crossing method (Figure 23)
Where the surface of the ground is relatively flat, locate the crossing point of two strings so that it matches the survey point on the top of the stone marker, and fix the strings to posts. Then, remove the strings and dig a hole for burying the marker. Replace the strings and bury the marker while positioning the center of the marker at the cross point of the strings. Where the surface is inclined, apply the method using two compasses instead of the strings and posts.

b. The direction and method of burying the marker should be such that the side of the post on which the FE boundary mark has been made should face toward the adjacent land.

c. Roughly 4/5 of the length of the marker should be buried in the ground. When the marker is buried along the side of a road, the depth should be adjusted in accordance with the situation and be reinforced by ramming it in using a ramrod after pebbles have been placed in the hole.

d. When it is difficult to bury markers at such locations as eroded riverbanks or where the danger of collapse exists, or where existing markers have to be removed due to construction work, preliminary markers should be installed. The preliminary markers should be installed inside the boundary line where they can be managed safely. The

preliminary markers should be surveyed from the boundary points before and after insertion, while the survey is conducted from the preliminary markers and the boundary points.

e. Auxiliary points should be installed when necessary as follows for maintaining and controlling the boundaries. Auxiliary points should be installed exactly on the boundaries.

a) When the distance between boundary points is 50 m or more,
b) When a mountain side boundary could be erroneously recognized as a horizontal boundary,
c) When boundaries are difficult to observe as they lie in valleys or on mountain ridges,
d) When it is considered that a conflict over the boundary is liable to occur.

① String ② Post ③ Drawing 25 ④ Drawing 29 ⑤ Ramrod
⑥ Marker ⑦ Pebbles ⑧ Compact pebbles and ram them
⑨ Bury the marker up to 4/5 of its length

5-3 Temporary removal or restoration of boundary markers

It sometimes becomes necessary for boundary markers to be temporarily removed or for a long periods due to road or dam construction. When they have to be removed, the boundary markers to be removed should be inspected to confirm that there are no problems. The inspection should be conducted in the presence of the person in charge of FE control and management, and a record should be kept and maintained. The person in charge of the site alone should not conduct the removal of the boundary markers. It is necessary that the procedure and regulations regarding marker removal should be clearly stipulated by the FE. When the reason for the temporary removal no longer exists, the boundary markers should be restored immediately.

5-4 Change of boundary marker numbers

As the location of boundary marker numbers has to be clearly defined along with entry in the register book, they should not be changed without significant reason. The procedure and regulations for this should be clearly instituted, so that when a change becomes necessary, the approval of the person in charge of the FE control and management is available to ensure that the amendment of the book is properly carried out according to the procedure.

6. Maintenance (Inspection)

It is assumed that boundaries can sometimes be moved artificially or due to natural causes, or be carried away by somebody over a long period of time. Therefore, boundary markers must be inspected regularly, so that damage or loss can be identified immediately and the markers can be quickly restored. The work for correctly restoring the markers to their original position is referred to as an inspection survey.

6-1 Purpose of the inspection survey

Boundary lines are for determining the ownership limits of land. While boundary markers are installed at the site to clearly indicate the boundary, boundary surveys are conducted and boundary related books are prepared and maintained as the means of securing the boundary through the numerical management of the boundary points. It is necessary to carry out strict inspection and rigid management of boundaries to prevent conflicts between adjoining landowners.

6-2 Inspection rules for preserving boundaries

Various types of inspections should be carried out in accordance with the characteristics of the boundaries. Considering this, depending on the persons who own the adjoining land, there are variety of possibilities in which boundary posts become damaged or the forests of the Forest Enterprise are encroached upon, the inspection of trouble prone areas should be reinforced for the early detection of such encroachments. These are the important reasons of the inspections.

6-3 Inspection

The inspections should be conducted regularly under fixed rules. The rules include one or more inspections per year on the condition of preservation of the boundary markers in the boundary marker or boundary intrusion prone areas (areas where farmlands are present nearby), entry of the date of the inspection, problems encountered, and changes in land utilization in the area nearby into the book. The inspector should take with him a copy of the maps on which the positions of boundary markers are recorded, the inspection book which records the past inspection records, a compass and a tape measure. The inspector should visually inspect or actually measure any problems with

the boundary or boundary markers and enter the result into the inspection book.

Items to be covered by the inspection are as follows.

a. Applications of paint on the marker and examination of the state of the boundary marker.

b. If anything is unclear, an inspection survey is to be conducted as described in the “Boundary inspection survey” for further investigation. When a boundary marker is missing, install a preliminary post at the point measured, and enter the matter into the book, as well as reporting the matter to the person in charge of the FE forest management.

c. Paint a mark on a tree near the boundary post (within 2 m distance inside the boundary), or post a boundary indication board, to clarify the boundary.

d. Cut the grass and bushes within 1 m of the boundary markers, and if necessary mow the land along the boundary.

6-4 Boundary record

Any relevant circumstances related to the adjoining land should be recorded. It is necessary to arrange the book for any successor in the management to know about boundary marker restoration when markers have disappeared and important places for inspection.