TẠP CHÍ KHOA HỌC
TRƯỜNG ĐẠI HỌC QUY NHƠN

Thành lập lưới khống chế trắc địa khu vực Trường Đại học Quy Nhơn

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TÓM TẮT

Lưới khống chế trắc địa khu vực Trường Đại học Quy Nhơn (ĐHQN) được thành lập bằng công nghệ GNSS và công nghệ toàn đạc điện tử, kết hợp với phương pháp đo cao hình học từ giữa, mốc lưới được xây dựng bằng bê tông vững chắc, có nắp sứ định tâm. Lưới gồm 11 điểm, trong đó có 2 điểm được dẫn chuyền từ điểm địa chính cấp I, dùng làm các điểm khởi tính cho đường chuyền. Lưới được xây dựng theo phương pháp toàn đạc với 2 lượt đo đi và đo về; độ cao thủy chuẩn của lưới được đo đạc theo phương pháp đo cao hình học từ giữa, đảm bảo theo đúng quy trình, quy phạm của Bộ Tài nguyên và Môi trường. Kết quả nghiên cứu gồm hệ thống các điểm lưới ổn định vững chắc, kèm theo tọa độ và độ cao thủy chuẩn được bình sai chặt chẽ bằng các phần mềm chuyên ngành, sơ đồ lưới khống chế. Lưới khống chế trắc địa khu vực trường ĐHQN có ý nghĩa quan trọng trong việc thành lập bản đồ, bình đồ, quy hoạch, xây dựng và phục vụ công tác giảng dạy, nghiên cứu khoa học của trường.

Từ khóa: *Lưới khống chế, tọa độ, trắc địa, bản đồ, bình sai.*

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QUY NHON UNIVERSITY
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Establishment of geodetic control network for Quy Nhon University area

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ABSTRACT

Geodetic control network of Quy Nhon University (QNU) is established based on GNSS technology and electronic total station technology in combination with the middle geometrical elevation surveying method, bench mark of network built with firm concrete installed with a centralized insulator cap. The network consists of 11 points, of which 2 points are traversed from the cadastral point of class I, used as the starting points for the traverse. The network is built based on total station method with 2 turns of forward and backward surveying. The network's leveling height is measured by the middle geometrical elevation surveying method, ensuring compliance with the procedures and rules of the Ministry of Natural Resources and Environment. The research result includes a system of stable and solid network points together with the coordinates and the leveling height that are closely adjusted by specialized software, control network diagram. Geodetic control network of the QNU is important in setting up map, general plan, planning, construction and serving for teaching and scientific research of the university.

Keywords: *Control network, coordinates, surveying, map, adjustment.*

1. INTRODUCTION

Geodetic control network plays an important role in setting up map, general plan, planning, and construction, etc. In teaching and scientific research, geodetic control network plays an important role in facilitating students in practicing the surveying, data processing, building cadastral map and topographic surveying. Quy Nhon University (QNU) offers a number of majors such as Land Management, Natural Resources and Environment Management and Construction. However, in the university campus, there is currently no fixed geodetic control network system with the coordinates and leveling height of the points, so it is very difficult for the process of teaching subjects related to geodesy, and it is quite hard for lecturers to check the result after students practice the surveying. Therefore, the construction of a fixed geodetic control network for Quy Nhon University is a necessary and meaningful job.

The research result includes a system of stable and solid network points together with the coordinates and the leveling height closely adjusted by specialized software, control network diagram. This will be an important document not only for teaching and scientific research but also it is an important source of data with high accuracy for the planning and construction of works in the campus of Quy Nhon University.

2. RESEARCH METHODS

The article uses the following research methods:

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- *Investigation and collection of data and documents* to investigate, and collect necessary data and information for the research such as cadastral map, high-level coordinating elevation points, conditions of surveying area, etc.

- *Surveying:* Use GNSS surveying method (static and dynamic surveying), total stastion method, middle geometrical elevation surveying method to establish the geodetic control network for Quy Nhon University. The given result is the unrefined result, which is the basis for data processing to give the result as coordinates and elevation with 11 network points.

Static surveying method uses 2 national coordinates to pass the coordinates and elevation to 2 cadastral points built for Quy Nhon University, namely DHQN and DHQN-A5, the surveying time for each station is 60 minutes. Each surveying turn consists of 3 points forming a triangular network, meeting the regulations on cadastral network surveying of the Ministry of Natural Resources and Environment.

The coordinates and elevation traverse survey from the cadastral points QNU-A5 for 2 points QNU.01 and QNU.02 uses the method of dynamic surveying, real-time RTK, using clamps to ensure accuracy for surveying results.

Total station method is used to determine the angles and edges of the traverse. The survey at each surveying station consists of 2 turns of forward and backward survey with 2 halves of a surveying turn, taking the average of the survey result will give value for adjustment.

Geometrical elevation surveying method is used to determine the elevation between two surveying points. Level gauge is placed between two surveying stations with relatively equal distance, minimizing errors caused by surveying instruments and external conditions.

- *Data processing:* Used in processing surveyed data in field and assessing error of surveying result. For data processing, specialized software such as TBC, PRONET, DPSurvey will be used to adjust surveying results, give final data and evaluate the error level of such results.[1]

- *Mapping:* Used to edit geodetic control network diagram under the specified specifications and scale. Network diagram will be edited on Microstation SE software at 1: 500 scale, for later detailed surveying.[1,2]

- *Field:* After surveying, data processing and edition of the network diagram, the field check will be conducted so that the study can be adjusted accurately and in accordance with the reality.

3. RESEARCH RESULT

3.1. Design of geodetic control network for Quy Nhon University

Quy Nhon University is located in Nguyen Van Cu ward, Quy Nhon city, Binh Dinh province. The university has a quite beautiful location and a wide campus close to Quy Nhon beach with an area of more than 14 hectares, with its East borders the East Sea, its West borders Nguyen Thi Dinh Street, its South borders Quy Nhon College of Engineering and Technology, its North borders the residential area. The topography of the university is relatively flat, which is a favorable condition for the design and surveying process of geodetic control network.

3.1.1. Investigation and collection of documents and data

In order to serve the surveying of the geodetic control network of Quy Nhon University, an investigation of the surveying area is conducted to assess the advantages and disadvantages of the topography and geophysics for the surveying process. In general, the topography is not too complicated, so the arrangement of the network is not quite difficult.

Through the investigation, collection of documents and data, there are 2 high-level points, belonging to the National coordinate network with numbers 875408 and 875413, which is the basis for passing the coordinates and the elevation to the geodetic control points built within the campus of Quy Nhon University.

Table 1. National coordinate points

Ordinal	Point Symbol	Coordinate		Elevation	Point position
		X (m)	Y (m)	H (m)	
1	875408	1524516.834	603058.892	127.943	Ba Hoa Mountain
2	875413	1518732.226	603855.356	98.386	Qui Hoa Slope pass

(*Source: Department of Natural Resources and Environment of Binh Dinh Province*)

3.1.2. Control point passing

The surveying and passing for two control points of Quy Nhon University are conducted based on the GNSS network establishment standard of the Ministry of Natural Resources and Environment. The surveying and passing of the coordinates and the elevation are conducted for 2 points to be the control points, namely QNU and QNU-A5. These two control points are traversed in May 2016.

Prior to the survey, it is required to conduct scheduling for the surveying area with the minimum simultaneous surveying time on a point of surveying station. The GNSS receiver used for the surveying of traverse points is two-frequency Trimble R4. The survey is carried out under the static survey method with 3 receivers. Each surveying turn satisfies the following conditions:

+ Minimum simultaneous surveying time: 60 minutes

+ Minimum number of continuous strong satellites: 4 satellites

+ PDOP selects when maximum surveying value does not exceed 4.0

+ Threshold of satellite elevation angle is larger than: 15º

Surveying result is saved in each receiver, then transferred to a computer by each file to serve for the adjustment.[3,4]

❖ *Adjustment of traverse points*

The traverse points for Quy Nhon University are processed and calculated by the software Trimble Business Center (TBC), which is allowed by the Ministry of Natural Resources and Environment to be used to adjust the GNSS surveying result, achievement of coordinates and elevation calculation under VN-2000 coordinate system, projection 3^0, 108^0 15' meridian.[1]

Calculation result is shown in table 2 as follows:

Table 2. Summary of surveying accuracy evaluation results

1. Unit weighted square error:	$M_0 = 1.000$		
2. Point position error:			
□ Minimum:	mp_{min} =	0.008m	(Point: DHQN-A5)
□ Maximum:	mp_{max} =	0.008m	(Point: DHQN-A5)
3. Edge relative error:			
□ Minimum:	ms/s_{min} =	1/560305	(Edge: 875413_DHQN, S = 3226.9m)
□ Maximum:	ms/s_{max} =	1/118902	(Edge: DHQN_DHQN-A5, S = 272.8m)
4. Azimuth error:			
□ Minimum:	ma_{min} =	0.41"	(875408_DHQN)
□ Maximum:	ma_{max} =	1.48"	(DHQN_DHQN-A5)
5. Elevation difference error:			
□ Minimum:	mdh_{min} =	0.006m	(DHQN_DHQN-A5)
□ Maximum:	mdh_{max} =	0.021m	(875413_DHQN-A5)
6. Edge length:			
□ Minimum:	S_{min} =	272.800m	(DHQN_DHQN-A5)
□ Maximum:	S_{max} =	3226.906m	(875413_DHQN)
□ Medium:	S_{tb} =	3081.044m	

After calculation and preliminary evaluation of the surveying result as above, we continue to evaluate the accuracy of the traverse points. Evaluation result is shown in the table 3:

Table 3. Evaluation of the result of adjusting traverse points

Ordinal	The technical indicators	Allowed limitation of error [1]	Results	Evaluation
1	Point position error after adjusted	≤ 5 cm	0,8 cm	Satisfy
2	Edge relative error after adjusted	≤ 1/50000	1/118902	Satisfy
3	Azimuth error after adjusted	≤ 5"	1.48"	Satisfy
4	Elevation difference error after adjusted	≤ 10 cm	2,1 cm	Satisfy

Table 3 shows the result of general evaluation of the established traverse points that shows the technical specifications and the allowable limits of each indicator, and then compares with the result of the network after being adjusted and finally judges, evaluates whether to satisfy or not. Under the above evaluation result, the traverse points set up for Quy Nhon University gave surveying result with high accuracy, ensuring the permissible limit. The result of Table 3 also showed the progress of TBC software in the adjustment and accuracy assessment of surveying results.[1,5]

The final result of the elevation control network adjustment is the coordinates and elevation of the traverse points in field. This is an important data for the survey work of Quy Nhon University.

Table 4. Result of calculating flat coordinates and elevation after being adjusted

Ordinal	Point Symbol	Coordinate		Elevation
		X (m)	Y (m)	H (m)
1	875408	1524516.834	603058.892	127.943
2	875413	1518732.226	603855.356	98.386
3	DHQN-A5	1521758.520	604332.399	27.692
4	DHQN	1521877.165	604578.048	22.513

Table 4 summarizes the results of the coordinates and elevation of the control points traversed to Quy Nhon University after detailed adjustment, calculation and accuracy evaluation of the criteria of the network. These are the basic points serving the establishment of the fixed geodetic control network for Quy Nhon University.

3.2. Establishment of geodetic control network for Quy Nhon University

3.2.1. Establishment of coordinate control network for Quy Nhon University

❖ *Arrangement and surveying of theodolite traverse*

Based on the available data in combination with the field investigation, the establishment of geodetic control network for Quy Nhon University is conducted. Firstly, based on the distribution of the existing basic points in combination with topographic conditions to subdivide to establish geodetic control network types. Arrange appropriate control networks depending on the actual topographic conditions of each area, the geodetic control network

established for Quy Nhon University is a network with a closed graph.

The geodetic control network for the entire area of Quy Nhon University includes 11 points, of which 2 points of QNU.01 and QNU.02 subject to traverse coordinates and elevation surveying by GNSS technology from QNU-A5 point are used as the starting points for the traverse types. The coordinate network is surveyed under total station method with 2 turns of forward and backward surveying, with 2 halves of a surveying turn, ensuring the process and rules as specfied by the Ministry of Natural Resources and Environment of Vietnam. In addition, in order to determine the elevation of the control points, the middle geometrical elevation surveying is carried out, the surveying result is closely adjusted, ensuring accuracy as regulated by the Ministry of Natural Resources and Environment.[1,6]

Table 5. Coordinates and elevation of the traverse points as the starting point

Ordinal	Point Symbol	Coordinate		Elevation
		X (m)	Y (m)	H (m)
1	QNU.01	1521725.116	604460.212	5.812
2	QNU.02	1521708.434	604535.057	6.135

❖ *Control network surveying*

The coordinate control network of the entire area of Quy Nhon University includes 11 points, of which 2 original points that have the coordinates traversed are used as starting points for the traverse network. The network is built under total station method with 2 turns of forward and backward survey with 2 halves of a surveying turn, ensuring compliance with the process and rules of the Ministry of Natural Resources and Environment.[1,8]

After the control points in the traverse are designed, we use TOPCON-GTS 230N electronic total station to survey the traverse under total station method. A traverse twice, forward and backward survey with 4 halves of a bidirectional surveying turn. The surveying result is averaged and adjusted by ProNet software, the adjustment result in the data sheet is attached with accuracy evaluation sheet of the surveying result.[7] Surveying result is shown in Table 6.

Table 6. Result of coordinate control network survey of Quy Nhon University

Measuring station	Point	horizontal angle reading		2C (<15")	Horizontal angle	Distance (m)		Average distance
		Right	Left			Right	Left	
QNU.01	QNU.10	00 00 00	180 00 00	0	201 15 20	64.639	64.640	64.639
	QNU.02	201 15 19	30 15 21	2		73.541	73.541	73.541
QNU.02	QNU.01	00 00 00	180 00 05	5	78 25 19	73.540	73.541	
	QNU.03	78 25 21	258 25 22	1		97.242	97.241	97.242
QNU.03	QNU.02	00 00 00	179 59 55	5	106 32 22	97.241	97.242	
	QNU.04	106 32 24	286 32 29	5		94.291	94.291	94.291
QNU.04	QNU.03	00 00 00	180 00 00	0	268 40 35	94.291	94.292	
	QNU.05	268 40 32	88 40 38	5		86.170	86.171	86.170
QNU.05	QNU.04	00 00 00	180 00 06	6	205 15 46	86.169	86.171	

Measuring station	Point	horizontal angle reading		2C (<15")	Horizontal angle	Distance (m)		Average distance
		Right	Left			Right	Left	
	QNU.06	205 15 44	25 15 52	8		77.143	77.143	77.143
QNU.06	QNU.05	00 00 00	180 00 04	4	35 20 18	77.142	77.143	
	QNU.07	35 20 19	215 20 21	3		134.791	134.792	134.791
QNU.07	QNU.06	00 00 00	180 00 00	0	105 34 47	134.791	134.791	
	QNU.08	105 34 49	285 34 45	4		135.412	135.412	135.412
QNU.08	QNU.07	00 00 00	180 00 05	5	196 35 19	135.412	135.411	
	QNU.09	196 35 20	16 35 23	3		126.703	126.703	126.703
QNU.09	QNU.08	00 00 00	180 00 00	0	83 24 45	126.703	126.702	
	DC-II.2	83 24 44	263 24 46	2		90.589	90.588	90.589
DC-II.2	QNU.09	00 00 00	180 00 03	3	257 41 49	90.590	90.589	
	QNU.10	257 41 48	77 41 53	5		33.418	33.417	33.418
QNU.10	DC-II.2	00 00 00	180 00 04	4	81 13 25	33.418	33.418	
	QNU.01	81 13 26	261 13 28	2		64.640	64.639	64.639

❖ *Calculation of the traverse network adjustment*

After finishing coordinate control network surveying of Quy Nhon University and obtaining specific data on aspects in the network, we use Pronet software to conduct the summary as well as detailed adjustment of the surveying control network.

```
                THEODOLITE TRAVERSE CHECK
                ============***===========
1.Route:  QNU.01_QNU.02_QNU.03_QNU.04_QNU.05_QNU.06_QNU.07_QNU.08_
          QNU.09_DC-II.2_QNU.10_QNU.01_QNU.02
          Route length        [S] = 1013.939 (m)       N =  11
          Azimuth closure     Wb = -15"                W(g/h) =  63.25"
          coordinate closure  fx = -0.007 (m)          fy     = -0.006 (m)
                              fp = 0.009 (m)           fs/[S] = 1/5400
          ------------------------------------------------------------
             Angular error (Ferero)     Mb =    1.364"
             Edge error                 Ms =    1.041 (cm)
             average edge length        S(tb)=   92.176 (m)
             ---------------------------------------------
```

Figure 1. Result of control network summary

The entire coordinate control network of Quy Nhon University includes 11 control points, including 2 known points and 9 surveying points. The network has a closed traverse shape. The result of evaluating the result of the coordinate control network summary of Quy Nhon University are synthesized in Table 7:

Table 7. Evaluation of the result of coordinate control network summary

Ordinal	The technical indicators	Allowed limitation of error [1]	Results	Evaluation
1	Azimuth closure error	$\pm 30'' \sqrt{n}$	± 5" to ± 57"	Satisfy
2	Coordinates closure error	1/2500	1/5400 – 1/3500	Satisfy

Table 7 showed that the results meet the required technical requirements, the calculation errors were much smaller than the allowed errors in the cadastral mapping regulations of the Ministry of Natural Resources and Environment, therefore the following steps can be adjusted to evaluate in a more detailed manner the errors of the control points in the traverse.[1]

After conducting the adjustment of the coordinate control network of Quy Nhon University on Pronet software, the result is summary tables of data on surveying value, adjustment value, coordinates of points and error types... The result of evaluating technical indicators of the geodetic control network of Quy Nhon University are synthsized in Table 8:

Table 8. Evaluation of the result of coordinate control network adjustment

Ordinal	The technical indicators	Allowed limitation of error	Results	Evaluation
1	Shortest side length	≥ 20 (m)	33.418 (m)	Satisfy
2	Longest side length	≤ 250 (m)	135.412 (m)	Satisfy
3	Mean square error easuring edge after adjustment	0,020 m	≤ 0,015 m	Satisfy
4	Minimum angle	≥ 5°	35°20’18’’	Satisfy

The result of calculating traverse types in the coordinate control network of Quy Nhon University has technical indicators that meet the regulations of the Ministry of Natural Resources and Environment, which can be used to edit the geodetic control network for the area. The adjustment result is shown in Figure 2:

RESULTS OF CALCULATION FOR THE SURVEY NETWORK

Ordinal	POINT SYMBOL	COORDINATE X(m)	COORDINATE Y(m)	LOCATION ERROR Mx	LOCATION ERROR My	LOCATION ERROR Mp
1	QNU.03	1521817.346	604545.322	0.008	0.007	0.012
2	QNU.04	1521886.892	604481.665	0.001	0.009	0.029
3	QNU.05	1521956.453	604532.532	0.007	0.005	0.014
4	QNU.06	1521976.775	604606.939	0.006	0.003	0.011
5	DQN.07	1522012.403	604476.941	0.007	0.001	0.011
6	QNU.08	1521895.632	604408.385	0.005	0.001	0.013
7	QNU.09	1521810.974	604314.117	0.005	0.007	0.010
8	DC-II.2	1521764.286	604391.749	0.005	0.003	0.012
9	QNU.10	1521731.615	604398.724	0.009	0.006	0.017

Figure 2. Result of calculating the surveying control network by Pronet software

From the result of the coordinates of control points, it is possible to edit the surveying control network diagram for the area. The geodetic control network of Quy Nhon University consists of 11 points, the control points are distributed throughout the area, their density satisfies with the detailed surveying.

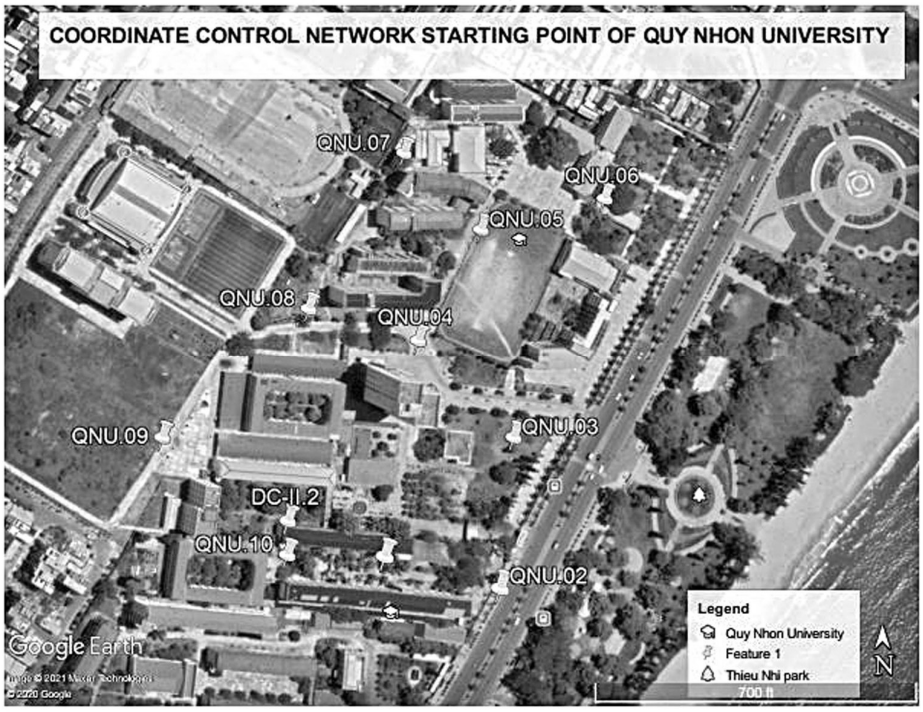

Figure 3. Coordinate control network starting point of Quy Nhon University

3.2.2. Establishment of elevation control network for Quy Nhon University area

❖ *Control network surveying*

Elevation control network for Quy Nhon University area is surveyed based on the established network points of the coordinate control network, thereby forming a fixed coordinate network system for the surveying area. Two datum points that have known elevation are QNU.01 and QNU.02.

The surveying of elevation control network and use of the level gauge to survey the middle geometric elevation for control points are conducted in accordance with the process and regulations. After surveying the elevation many times among the control points, the following result is obtained:

Table 9. Data of surveying of elevation control points

Measurement route	Point behind	Point forward	Distance (m)	Height difference (m)
QNU.01_ QNU.02	QNU.01	QNU.02	73.541	-0.003
QNU.02_ QNU.03	QNU.02	QNU.03	97.242	-0.053
QNU.03_QNU.04	QNU.03	QNU.04	94.291	-0.173
QNU.04_ QNU.05	QNU.04	QNU.05	86.170	1.684
QNU.05_ QNU.06	QNU.05	QNU.06	77.143	-0.934
QNU.06_ QNU.07	QNU.06	QNU.07	134.791	-0.809
QNU.07_ QNU.08	QNU.07	QNU.08	135.412	0.156
QNU.08_ QNU.09	QNU.08	QNU.09	126.703	0.188
QNU.09_ DC-II.2	QNU.09	DC-II.2	90.589	-0.048
DC-II.2_ QNU.10	DC-II.2	QNU.10	33.418	0.037
QNU.10_QNU.01	QNU.10	QNU.01	64.639	-0.045

Table 9 shows the result of field surveying with Pentax AP-281 level gauge with an accuracy of ± 2.0mm, the use of middle geometrical elevation surveying method to ensure high accuracy and in accordance with regulations of the Ministry of Natural Resources and Environment. The determination of the leveling elevation of newly established control points is performed by determining the elevation among the points, starting from the known cadastral point QNU.01. However, the process of determining the elevation among control points is not the same and it's required to arrange suitable surveying methods depending on the topography as well as the distance between the surveying stations. Only one surveying station is required for short surveying stations with favorable terrain while sub-stations are required to ensure accuracy for the stations with complicated topography and a long distance. After surveying in field, the data will be processed to gain the elevation among the established control points (Table 9).

❖ *Calculation of traverse network adjustment*

After collecting the necessary data and conducting field surveying, we use DPSurvey 3.2 software to process data. The result after the adjustment is shown in Table 10:

Table 10. Surveying value and quantities after adjustment

Ordinal	Point behind	Point forward	Measured value	Correction number	Adjustment value	Mean square error
	(i)	(j)	(m)	(mm)	(m)	(mm)
1	QNU.01	QNU.02	-0.003	-1.0	0.323	1.2
2	QNU.02	QNU.03	-0.053	-0.8	-0.453	1.5
3	QNU.03	QNU.04	-0.173	-1.4	0.516	1.5
4	QNU.04	QNU.05	1.684	-1.0	1.541	2.0
5	QNU.05	QNU.06	-0.934	-0.7	-1.326	1.5
6	QNU.06	QNU.07	-0.809	-0.3	-0.463	1.7
7	QNU.07	QNU.08	0.156	-0.2	0.352	1.0
8	QNU.08	QNU.09	0.188	-0.5	0.257	1.2
9	QNU.09	DC-II.2	-0.048	-0.3	0.147	1.1
10	DC-II.2	QNU.10	0.037	-0.3	0.166	1.8
11	QNU.10	QNU.01	-0.045	-0.8	-0.060	1.5

Table 10 shows the corrective number (SHC) of the surveying values and the result of calculating the elevation among the control points after being adjusted. In addition, it also calculaties the mean squared error (MSE) of each surveying value. Elevation control network established for Quy Nhon University is an engineering elevation control network, thereby there is an allowed error: $f_{CF} = \pm 50\sqrt{L} = 50.347$ mm. The result of evaluating the accuracy of the result after the elevation control network adjustment shows that unit weighted MSE, MSE of the elevation and height of the weakest point are all very small compared to the allowed error. Thus, the surveying result ensure high accuracy and can be used to conduct the following calculation steps.[1, 9]

After calculating and preliminarily evaluating the surveying result as above, we continue to evaluate the accuracy of the established elevation control network. Evaluation result is shown in Table 11:

Table 11. Evaluation of elevation network adjustment result

Ordinal	The technical indicators	Allowed limitation of error[1]	Results	Evaluation
1	The length of the edge	≤ 150 (m)	135.412 (m)	Satisfy
2	The difference between the machine and the two yards	≤ 5 (m)	4.173 (m)	Satisfy
3	Accumulate the distance difference on the route	≤ 50 (m)	24.532 (m)	Satisfy
4	Beam height compared to the ground	≥ 0.2 (m)	0.212 (m)	Satisfy
5	High margin of error	≤ $\pm 50\sqrt{L\,(km)}$ = 50.347 (mm)	± 10 (mm)	Satisfy

Table 11 shows the result of the general evaluation of the established elevation control network, where technical indicators and allowed limits of each indicator are presented, then compared with the result of the network after adjustment and finally make judgment and evaluation whether to satisfy or not. According to the above evaluation result, the elevation control network established for Quy Nhon University area obtained surveying result with high accuracy, exceeding the permissible norms.

The final result of the elevation control network adjustment is the leveling height of the control points in field, together with the height of points is the mean error of each point.

Table 12. Elevation of point after adjustment

Ordinal	Point symbol	H(m)	Mean square error (mm)
1	QNU.01	5.616	0.0
2	QNU.02	5.613	0.0
3	QNU.03	5.560	1.7
4	QNU.04	5.387	2.1
5	QNU.05	7.071	1.4
6	QNU.06	6.137	1.5
7	QNU.07	5.328	1.2
8	QNU.08	5.484	1.3
9	QNU.09	5.672	1.4
10	DC-II.2	5.624	1.2
11	QNU.10	5.661	1.6

After the coordinates and leveling height of the points are obtained, we edit the geodetic control network for the study area using Microstation SE software, then conduct field check, survey and review in field, adjust the result and produce the map of fixed geodetic control network of Quy Nhon University area with the coordinate system and elevation of points as follows:

Table 13. Summary of coordinates and leveling height of geodetic control points

Ordinal	Point symbol	Coordinate		Elevation
		X	Y	H (m)
1	QNU.01	1521732.075	604463.364	5.616
2	QNU.02	1521720.562	604536.001	5.613
3	QNU.03	1521817.350	604545.326	5.56
4	QNU.04	1521886.895	604481.660	5.387
5	QNU.05	1521956.450	604532.530	7.071
6	QNU.06	1521976.768	604606.942	6.137
7	QNU.07	1522012.407	604476.945	5.328
8	QNU.08	1521895.635	604408.380	5.484
9	QNU.09	1521810.979	604314.112	5.672
10	DC-II.2	1521764.292	604391.743	5.624
11	QNU.10	1521731.610	604398.729	5.661

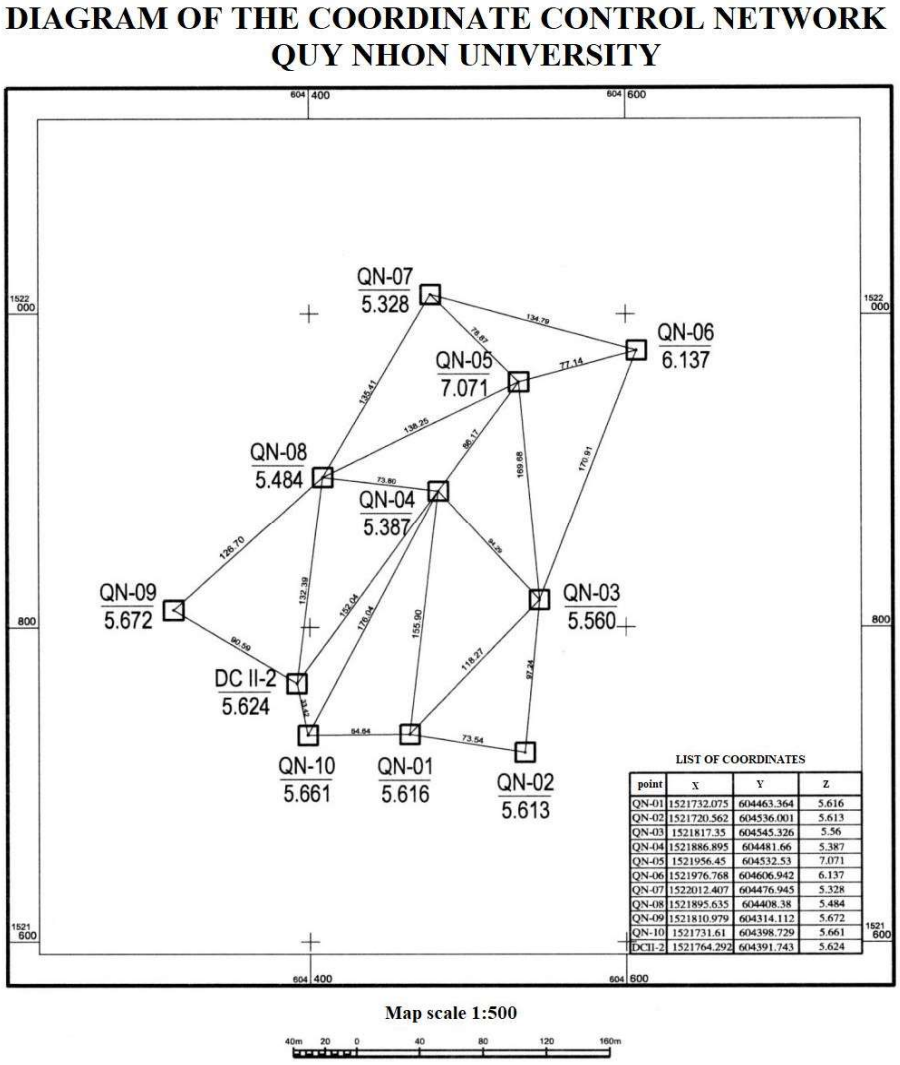

Figure 4. Diagram of the coordinate control network of Quy Nhon University

Figure 4. Diagram of the coordinate control network of Quy Nhon University

4. CONCLUSION

Through the process of researching, we built the fixed survey marks for QNU area with 11 starting points of solid concrete and a centralized insulator cap. These starting points have coordinates traversed by GNSS technology and total station technology in combination with middle geometrical elevation surveying method, then calculated and closely adjusted, ensuring compliance with the regulations of the Ministry of Natural Resources and Environment. The research result established a fixed geodetic network for GNU area with a system of control points having coordinates and leveling height determined exactly in field. The research result also established important documents for teaching and scientific research, and at the same time serving the planning and construction of items and works for Quy Nhon University area.

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