STUDYING THE FEASIBLTY OF TOTAL STATION IN ARCHITECTRAL SURVEY AS COMPARE TO THE CONVENTIONAL CLOSE-RANGE PHOTOGRAMMETRIC TECHNIQUE

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ABSTRACT

In this work, the total station survey and the analytical photogrammetry, were uesd in architectural photogrammetry.In this study, a test site was used for the comparison between the total station survey and the analytical photogrammtry and for experimental determination of the accuracy of the total station survey .Two facades from the test site were photographed with a metric camera, using single and convergent photographs. The accuracy of both the close range photogrammetry and the total station techniques in architectural surves was detrmined by, comparing the obtained coordinates with the original check points coordinates of the test site. The results indicated that, the total station technique results are conform with the correspond close range photogrammetric results, but more economic and simple to applied .
KEY WORD : Architectural photogrammetry; analytical photogrammetry; total station.

INTRODUCTION

There are many of the ancient Pharonic, Coptic, Roman and Islamic monuments in Egypt, which have a great importance for the whole world and at the same time, play an essential role in attracting tourists from other different parts of the world. Most of the monument in Egypt need to be restored, as the case of 'Al Fatimid - Cairo. For the purpose of the restoration, the monument should retain its original shape, otherwise, it would los its monuments value. One of the most convenient methods, which is used for the registration purposes,is the Close-Range Photogrammetry (analog, analytical and digital photogrammetry). Despite of the advantages of the Close- Range Photogrammetry,its use in Egypt is quite limited, because it needs, special experience, instruments, budget and great effort to regestrae the monuments .

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For all of these reasons, the aim of this study, is to find a reliable, simple, rapid,convenient and economic technique, which can be used for the purpose of the regisration of building exteriors (facades) in geometrical terms.

The aims of this study are:

-Studying the capability of the total station in architectural survey;

-Determining the group (According to the ICOMOS,there are three principal groups) of architectural survey, which can be achieved using the total station survey;

-Using the analytical photogrammetry in architectural photogrammetry; and

-A comparative study between the obtained results from the analytical photogrammetry, as a conventional method, and the total station survey.

BACKGROUND

According to the ICOMOS (International Council of Monuments and Sites) symposium in 1968, the architectural photogrammetry has been classified into three principal groups: rapid and relatively simple architectural photogrammetry surveys; precise surveys and very precise surveys Karara[89].

Rapid and relatively simple architectural photogrammetry surveys :

Surveys of this type are used in preliminary studies for restoration or development, in inventory work, in the study of the history of art, and in other situations. An accuracy on the order of 5 cm (Karara [89]) is often considerd sufficient . plotting is generally at scales of 1: 100 or 1: 200.

Precise surveys :

This second group of architectural photogrammetry surveys corresponds to the more general requirements of architects or art historians and is undertaken in the framework of surveys programs of conservation of heritage conucted by official organizations. Plotting is generally at a scale of 1:50 and the accuracy called for is 1 or 2 cm (Karara [89]) .

Very precise surveys :

Projects belonging to this third group are currently much fewer in number than projects belonging to either of the two previously discussed groups, particulary the second. The desired accuracy in this group is of 1mm and in some cases of 0.1mm (Karara [89]).

THE TEST SITE

To study, the capability of the total station of solving problem of architectural photogrammetry, the palace of EL GAZAR BASHA was used as a test site. The palace of EL GAZAR BASHA is situated in the center of the Menoufiya University and was erected as the first distinguished secular building in Shebin El-Kom in the year 1920 . Because of its location (optimum conditions for observations, no public transport area) it is particularly suited for testing the total station. The building has an rectangular- shaped ground plan and covers an area of about 35x50m,and its height is about 12m

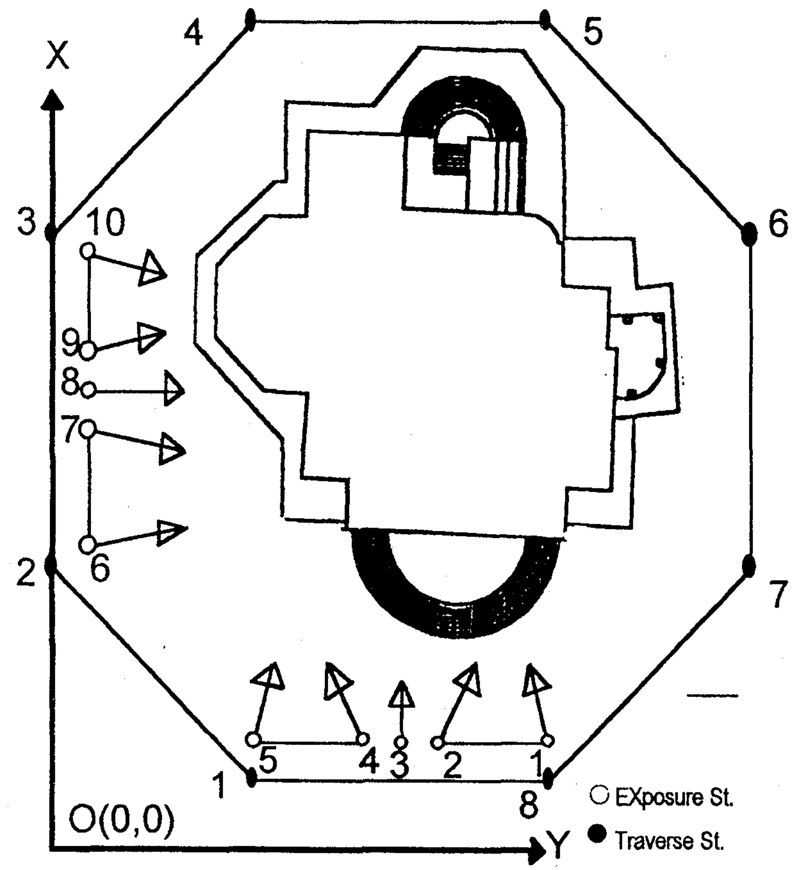


FIG.1 The local coordinate system and Photographic recording set-up

DETERMINATION OF THE TARGET COORDINATES

In this study, three different geodetic measurements had been carried out,which are:
Control point coordinates, check point coordinates and the total station observations (X_I,Y_I and Z_I) .As a basis of the geodetic determination of the control point coordinates , the check point coordinates and the total station observations in a uniform object system, a closed traverse around the building was established .The traverse side 2-3 is parallel to the respective east facade of the building,which corresponds to the X-axis of the local coordinate system (Fig.1) . The traverse angles were measured in one set using one second theodolite (Theo-10- A) from Jena . At the same time, the horizontal and vertical angles to the control and check points ,were measured at the points 1,8 and 2,3 of the traverse . The distance measurements of the traverse sides were taken twice using the subtance bar. The height of the traverse points were measured in a levelling loop by means of the Ni-07 from Jena,with the specifications of the precise levelling . On the basis of the calculated traverse point coordinates, the coordinates of the control and check points were subsequently determined by a personal computer IBM with the aid of the program "Space intersection". The program prepared by the auther, is used to determine the ground point coordinates, using the horizontal and vertical angles,

the three object coordinates (X_I,Y_I and Z_I), and the residual errors in Z direction . The coordinates of all check points of the test site and the residual errors were calculatede and listed in table (1) . Corresponding to the given instrument accuracies and the measurement results, the following mean square errors of points were obtained :

-for traverse points mp = ± 5 mm

- for control points mp = ± 2 mm

- for check points mp = ± 2 mm

TABLE 1. THE COORDINATES OF THE CHECK POINTS

NO	X(m)	Y(m)	Z1(m)	Z2(m)	Z(mean)	Z diference
1	9.8302	14.8712	12.1377	12.1422	12.1399	0.00225
2	4.8144	13.8151	11.3541	11.3580	11.3560	0.00195
3	9.8620	14.8148	12.2110	12.2158	12.2134	0.0024
4	3.2214	13.5505	11.1589	11.1622	11.1605	0.00165
5	6.8230	15.7627	12.2397	12.2445	12.2421	0.0024
6	7.8357	12.0122	14.6283	14.6316	14.6299	0.00165
7	3.6244	13.7053	9.7381	9.7429	9.7405	0.0024
8	7.8358	12.0199	1.0897	1.0958	1.09275	0.00305
9	6.3412	21.5041	1.2198	1.2246	1.2222	0.0024
10	5.2546	13.9510	14.0407	14.0455	14.0431	0.0024
11	5.4327	14.1184	13.6162	13.6201	13.6181	0.00195
12	5.4323	14.1200	11.4168	11.4201	11.4185	0.00165
13	9.7563	12.4546	14.7422	14.7465	14.7443	0.00215
14	6.6804	15.2203	15.4711	15.4754	15.4732	0.00242
15	4.8144	13.8151	11.3541	11.3578	11.3555	0.00242
16	2.7123	11.0642	6.2857	6.2890	6.2870	0.0013
17	2.7147	11.2440	5.4244	5.4286	5.4265	0.0021
18	2.2923	10.9438	1.0888	1.0929	1.09085	0.00205
19	2.2962	10.9626	1.0325	1.03425	1.03425	0.00175
20	7.4190	15.6438	12.1385	12.1436	12.1410	0.00255
21	5.2716	10.6848	1.0988	1.1023	1.10055	0.00175
22	14.6129	13.2907	10.5317	10.5360	10.5338	0.00215
23	12.3767	14.0799	8.8517	8.8570	8.85435	0.00265
24	14.5438	13.3957	2.5048	2.5097	2.50725	0.00245
25	10.6014	14.5114	0.4604	0.4645	0.46245	0.00205
26	14.5434	13.3956	2.5048	2.5083	2.50815	0.00335
27	10.6264	14.3824	13.7468	13.7497	13.7482	0.00145
28	10.7032	14.4813	13.7439	13.7462	13.7450	0.00115
29	10.5599	14.6408	11.3286	11.3321	11.3303	0.00175
30	4.0743	13.9966	14.9000	14.9039	14.9019	0.00195
31	13.3949	15.8912	2.7996	2.8038	2.80160	0.0022
32	5.4328	14.1496	9.7295	9.7328	9.73075	0.00125
33	3.2395	13.6319	15.4023	15.4056	15.4039	0.00165
34	3.3778	13.6439	14.0432	14.0483	14.0457	0.00255
35	13.3949	15.8912	2.7996	2.8038	2.80160	0.0022
36	4.0743	13.9966	14.9000	14.9039	14.9019	0.00195
37	4.6879	13.8882	13.8209	13.8242	13.8225	0.00165
38	7.1745	15.7202	11.3288	11.3351	12.6633	0.0016
39	6.7939	15.6936	12.6617	12.6649	12.6633	0.0016
40	9.6428	14.8068	13.8435	13.8496	13.8465	0.00305
41	9.6445	14.8054	13.7417	13.745	13.7433	0.00165
42	10.4456	14.5597	12.2811	12.2854	12.2832	0.00225

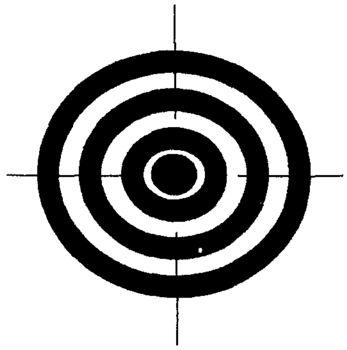


FIG. 2 The Taraget

PHOTOGRAMMETRIC SURVEY; MEASUREMENTS AND CALCULATIONS

Prior to measuring and taking photographs, all control points were marked and glued by targets (black - and white circular shaped targets (Fig. 2) in order to ensure a good measuring conditions . The control points were chosen such that at least 12 points were optimally distributed on two facades of EL GAZAR BASHA's palace (north and east facade) .In accordance with the local conditions, about 24 targets were glued to north and east facades of the object . The check points consists of 42 targets (20 fixed black- and white circular- shaped targets (Fig. 2), and 22 natural and good identified targets) .The check points are equaly distributed on the two facades of the test site .

Mathematical model

The mathematical model for the terrestrial photogrammetric triangulations in this work is based on The Collinearity equation using the bundle method .

COLLINEARITY EQUATION

The Collinearity equation is the mathematical representation of the transformation of a terrain point A (X,Y,Z) to the corresponding image point a (x,z), by a central perspective projection $O(X_o,Y_o,Z_o)$, and the rotation angles ω,φ,κ which are the parameters of exterior orientation. The inner orientation is defined by the focal length C and the position of the principale point p that is :

$$x = -C\frac{m_{11}(X-X_0) + m_{21}(Y-Y_0) + m_{31}(Z-Z_0)}{m_{13}(X-X_0) + m_{23}(Y-Y_0) + m_{33}(Z-Z_0)}$$

$$z = -C\frac{m_{12}(X-X_0) + m_{22}(Y-Y_0) + m_{32}(Z-Z_0)}{m_{13}(X-X_0) + m_{23}(Y-Y_0) + m_{33}(Z-Z_0)}$$

Where : C : is the camera constant ;
x,z : are the image coordinates;
X,Y,Z : are the object space coordinates ;
X_o,Y_o,Z_o : is the exposure station coordinate and;
m_{11} to m_{33} : are the elements of a matrix which is determined by the rotation parameters ω,φ and κ.

The unknown parameters can be computed by bundle adjustment. For this purpose, control points must be measured in the ground reference system, on one hand, and in the image coordinate system, on the other. All photographs were taken with the metric camera UMK 10/1318 from Zeiss Jena. The north and east facades of the palace of EL-GAZAR BASHA were recorded as a case study .The positions of the stereomodels and single photographs as well as the camera directions are shown in Figure (1).All photographs were taken from the ground.The photographs were measured on the Technochart-D from Jena. In order to increase the accuracy, double measurements are recommended for photos. In any case, the photo measurement accuracy is ±5μm.Ten exposure stations were established, eight in a convergent imaging configuration and two single photographs. The bases of the altogether 4 stereo pairs were so arranged that they were approximately parallel to the respective facades. The elevation view of the north and east facade of EL GAZAR BASHA's palace are shown in Figure (4) and (5).

TOTAL STATION SURVEYS AND MEASUREMENTS

PRACTICAL ASPECT

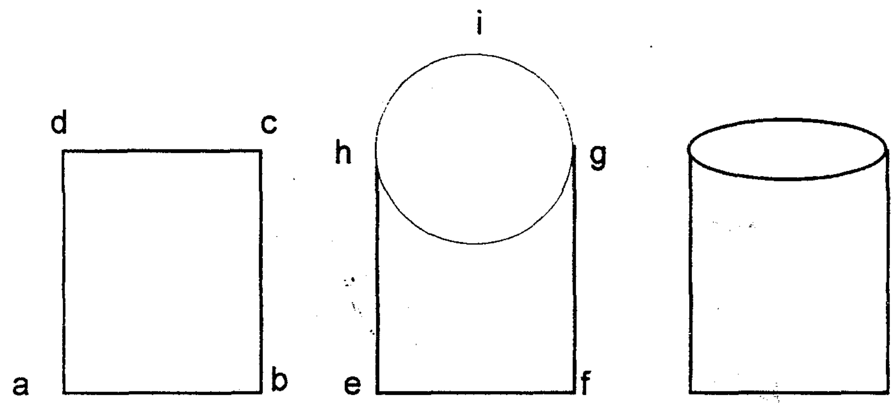
The idea of using the total station survey in architectural photogrammetry, based on the Meydenbauer method in architectural photogrammetry, this means that the total station survey can be carried out point - by point to get the coordinates of all points, which represent the object (measured drawing).In this study all total station observations were taken with the total station SET 3C from SOKIA. Reffered to the coordinate system of the closed traverse (Fig.1), the total station has been employed to determine the coordinates (X_I,Y_I and Z_I) of the necessary object points, which would be used to represent the two facades . In this work, a single reflector and a target sheet were used . In case of the height (Z) of certain objects, where the reflecting prism or the taraget sheet cannot usually be positioned, the remote elevation measurement function has been used to calculate the height above the ground using a point directly above or below the object.

Measuring openings

In this work, there are three different window openings which are to be measured. The one shown in Fig. (3.a) will present little difficulty, where points a, b, c and d are to be measured.The circular- headed openings shown in Fig.(3.b), there is no problems to determine the coordinate of points e,and f. The difficulty is to measure the curve, therefore the actual position of the points g,h must be firstly determined using the cross-hair of the total station, which must be tangent to the start point and the end point of the curve, and finally the coordinates of the three points g, h and I which lies on the curve must be measured. The same manner must be used for the opening,which has a segmental head Fig.(3.c).

COMPUTER GRAPHICS

The processed object space coordinates are then featured- coded with Auto CAD primetive commands: lines, B-spline, points, circles, layers, arcs, etc in an ASCII file. This code file, which is created interactively after the object space has been computed (in Analytical photogrammetry) or observed (in total station), is then routed to Auto CAD for automatic drafting. An example of the computer graphic with Auto CAD is shown in Fig.(6) and Fig.(7).



[Fig.3a] Rectangular

[Fig.3b] Circular-head

[Fig.3c] Segmental-head

FIG. 3 Three simple window openings

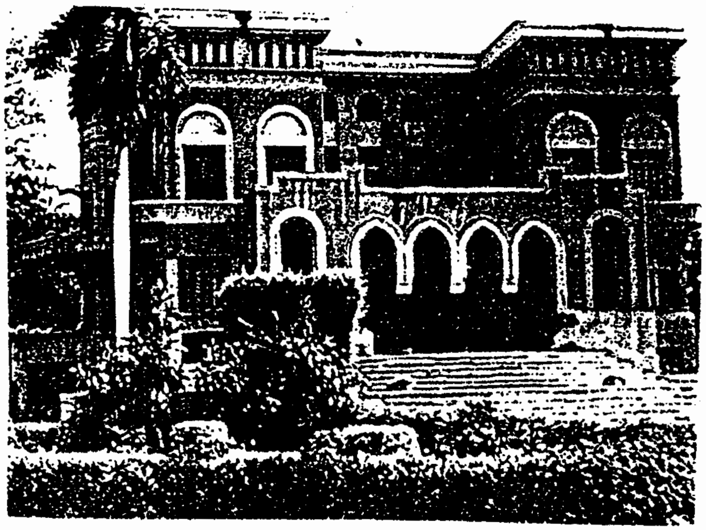


FIG.4 Photograph for the north facade of EL-GAZAR BASHA palace taken with UMK 10/1318

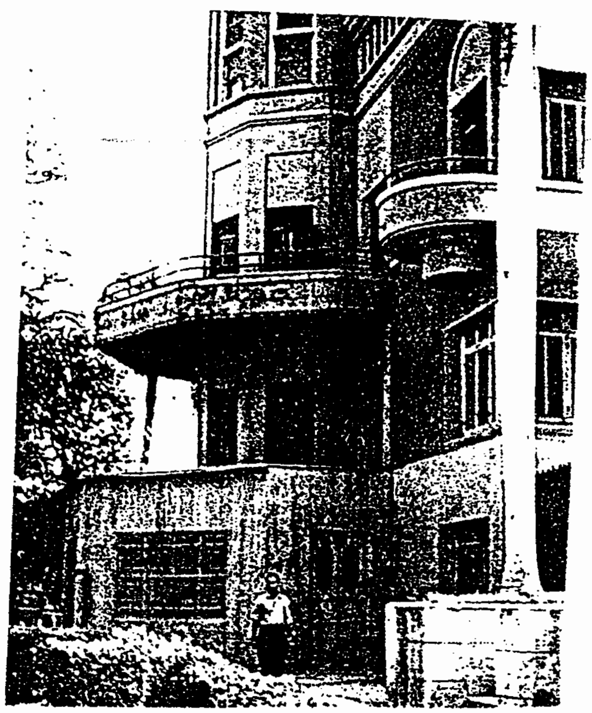


FIG.5 Photograph for the east facade of EL-GAZAR BASHA palace taken with UMK 10/1318

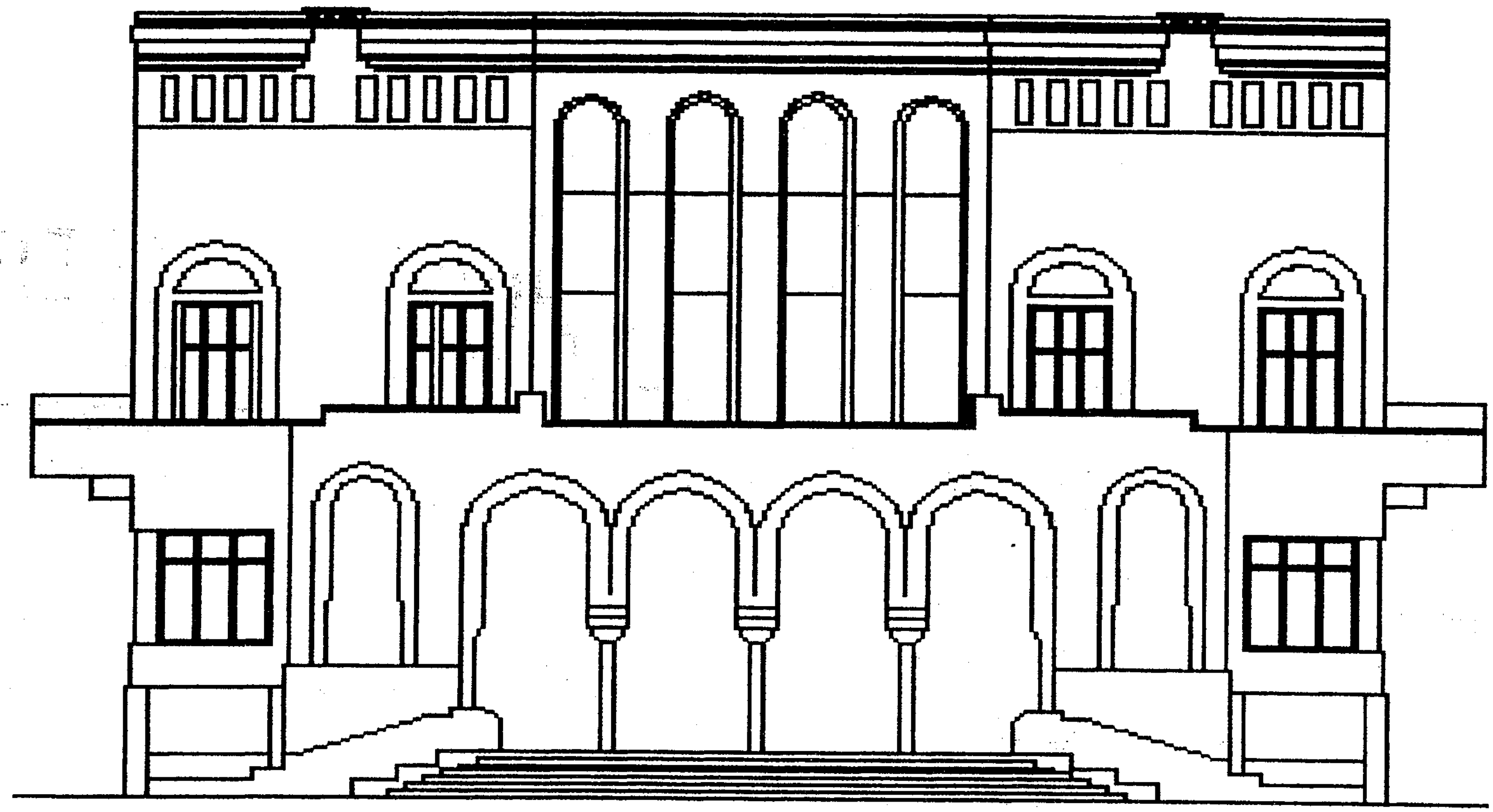


FIG. 6 The north facade of EL GAZAR BASHA palace

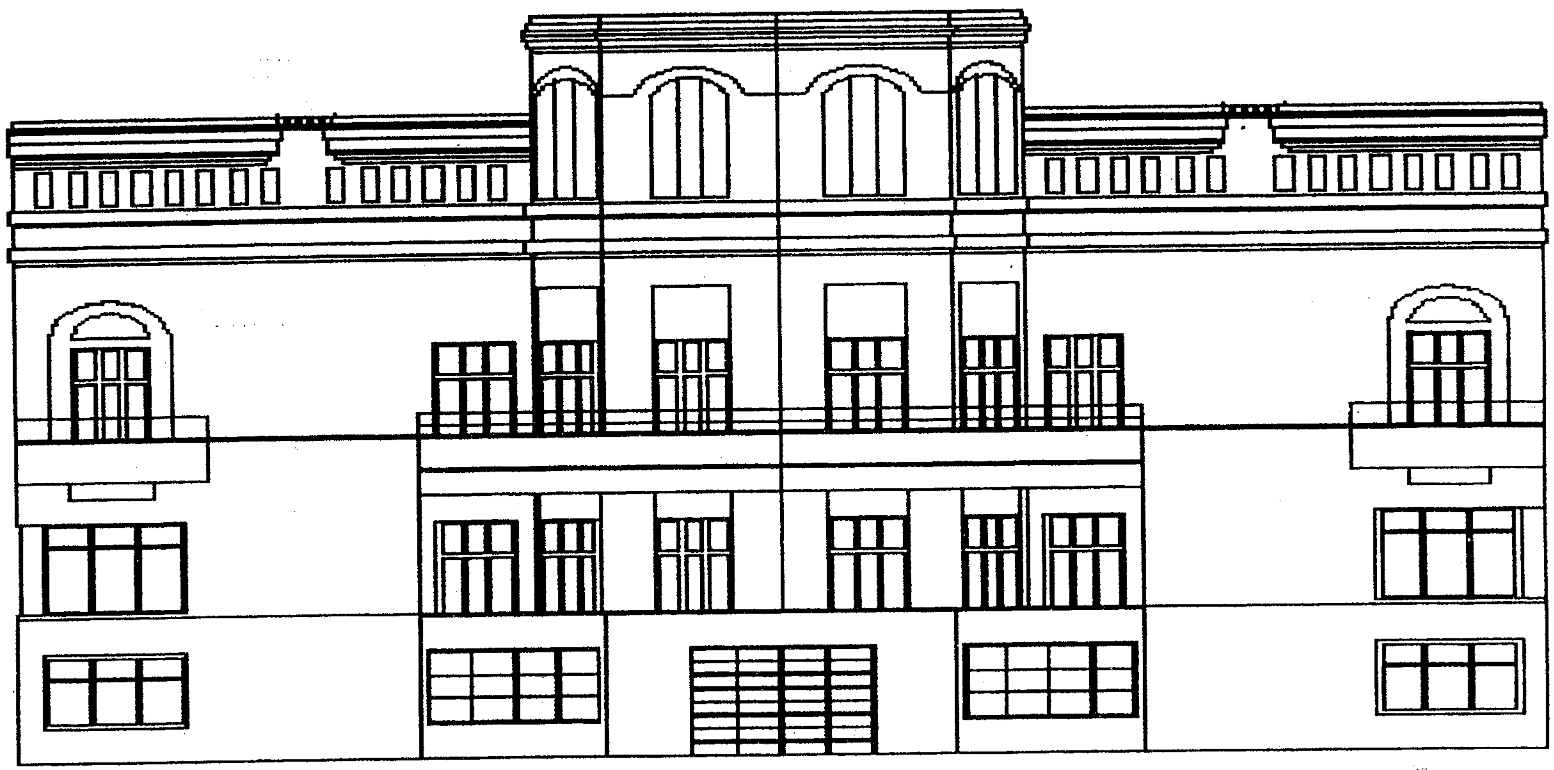


FIG.7 The east facade of EL GAZAR BASHA palace

DISCUSSION OF THE OBTAINED RESULTS

TABLE 2. THE COMPARISON BETWEEN THE TOTAL STATION SURVEY AND THE ANALYTICAL PHOTOGRAMMETRY

ITEM	TOTAL STATION	ANALYTICAL PHOTOGRAMMETRY
Number of necessary point to represent the two facades	1388 pts.	1388 pts.
Time need to drawing the two facades	$04^h\ 30^m\ 00^s$	$04^h\ 30^m\ 00^s$
Time need to get the object space coordinates	$12^h\ 30^m\ 00^s$	$32^h\ 20^m\ 00^s$
Material needed	No need	Films- Developing- Fixing- water-drying
Auxiliary Instruments	No need	Theodolite, Comparator (mono or stereo)
Extra program requirement	No extra program	Bundle adjustment
Control points or control distances	One control point for each facade	Minimum 3 control points for each facade and/ or control distances
Geodetic observations	local coordinate system	local coordinate system
Accuracy in term of RMS of coordinate differences	$2\text{-}7_{mm}$	$2-10_{mm}$
Beloning's group	2nd group	2nd group
The output form	Only map sheet to scale	Archieve Film (negative and positive)and MAP sheet to scale

TABLE (3) : STATISTICS OF OBTAINED COORDINATE DIFFERENCES BETWEEN BOTH ANALYTICAL PHOTOGRAMMETRY AND TOTAL STATION TECHNIQUES AT THE USE CHECK POINTS

Pt.	Total Station			Analytical Photogrammetry		
	ΔX	ΔY	ΔZ	ΔX	ΔY	ΔZ
1	1.13	1.51	1.16	1.38	2.9	2.15
2	1.31	1.43	1.28	1.48	1.73	1.48
3	1.41	1.82	1.6	1.2	1.63	1.24
4	0.98	1.37	1.01	1.43	1.85	1.48
5	1.1	1.54	1.36	1.24	2.54	1.39
6	2.01	1.71	1.71	2.35	1.75	1.98
7	1.02	1.03	1.21	1.29	1.58	2.23
8	1.01	1.31	1.26	2.55	1.87	1.34
9	1.2	1.47	1.31	1.39	1.54	1.44
10	1.3	1.39	1.1	1.38	1.81	1.52

RMS	Total Station	Analytical Photogrammetry
RMS(Maximum)	2	2
RMS(Minimum)	7	10

The coordinates which are computed from the total station survey and analytical photogrammetry are compared by the RMS- values of the coordinate differences in the check points. The comparison of results is shown in table (2) and table (3).

Regarding to the comparison between the total station survey and analytical photogrammetry,the following remarks can be stated :
-The obtained accuracy from the total station survey was found comparable with the corresponding accuracy obtained from the close- range photogrammetric results.
-In analytical photogrammetry, the instruments which are required for the photography and for measuring the image coordinates are very expensive by comparison with the total station.
-The accuracy of the analytical photogrammetry depends on the lay out of the two camera stations, number of stations, density of control points, the precision of the measured image coordinates and the focal length of the camera, but the accuracy of the total station depends on only the instrument and the operator .
-In analytical photogrammetry, one cannot reach the required accuracy for measuring the image coordinates by using small scale; and to overcome the scale problem in analytical photogrammetry, specially in the narrow streets ,the photographs can be taken from the ground, from scaffolding, from the roofs of neighboring buildings,or from a platform mounted on an elevating system and this means more budget more time and great effort, but in the total station , there is no limitations on the format size and intensity of light.
-In analytical photogrammetry, one often encounters some difficults, such difficults may be due to large depths of field compared with the average object distance and to the fact that, the image of the object covers only a part of the photograph, in the total station survey, there are no problem with the depth of field and the overlaps (minimum distance by the 3SET is 1.5m and maximum distance is 2000ms).
-The photographs contain a wealth of interpretable information; thus one can say that, the photogrammetric archives of the building assume an "intellectual conservation" of the building in its "effective shape", at a precise moment in its history, but The total station survey takes no account of perspective, but simply shows details and parts geometrically.
-The photographs are lasting documents from which, measurements can be derived at any time in the future; thus in case of the total station survey, sufficient measurements must be taken in the field to enable the whole to be draw out in the office. It can be most inconvenient and costly if further visits to the site have to be made, because important dimensions have been missed
.
-In case of the analytical photogrammetry, one need time to reconnaissence ; to plane the project and to determine the lay out of the camera stations, but in case of the total station survey, one needs only to reconnaissence the site.
-In both cases it is also very important to know how measurements are noted down, to enable the plotting process to be carried out successfully .
-The total station reduce the required time by about 50% in comparison with the analytical photogrammetry.

-The profitability of the total station survey is the higher, and the greater number of points to be measured.
-The total station can be used in any type of preliminary survey, control survey or layout survey beside in the architectural photogrammetry.

From the above discussions, one can say that by using the total station in architectur photogrammetry, not only working times saved, but also money for wages and materials. Therefore, one can advise to use the total station in architectural photogrammetry.

CONCLUSIONS

The test site has been successfully used for the comparison between the total station survey and the analytical photogrammetry in architectural photogrammetry .The presnted example show the feasiblty of the total station in architectural photogrammetry .The practical experiment has proved that ,the total station survey is considerably more simple, rapid and economic than using the close range photogrammetric technique. Moreover, the obtained accuracy from the total station survey was found comparable with the corresponding accuracy obtained from the close range photogrammetric results, therefor one can suggest to use the total station in architectural photogrammetry as a low - cost system.

REFERENCES

[1] Abdel- Gawad, A.K. (1994) " The Application of High precise Surveying Tecnique in Measuring Deformations of Structures" M.Sc. Thesis,Faculty of Engineering,Ain Shams University

[2] Behairy, A. M. and Zahran, M.I.,(1990) "Reliability for Close Range Photogrammetry " Proceeding of the First Conference on Civil Eng.,Volume 2, Military Technical College.

[3] Carbonnel,M. and Dallas,R.W.,1985 The International Committee for Architectural Photogrammetry (CIPA) : Aims,Achievements,Activities.Photogrammetria, 40(2): 193-202.

[4] Ebner , Fristsch and Heipke 1991 Digital photogrammetric systems .Wichmann verlag

[5] Karara ,H.,M. 1989 Non - topographic photogrammetry American Society for photogrammetry and remote sensing.

[6] Rahil,A.M. (1997) "A Comparative Study of Different Configuration Systems in Cose-Range Photogrammetry" Civil Engineering Research Magazine EL-AZhar Univ.,Vol.(19),No.5,1997

[7] Von Gelder, B.H., 1994, " Geodetic Control Survey: Lecture Notes ", Purdue University, Civil Eng. Dep.,West Lafayette, IN., USA

[8]Wester-Ebbinghause,W.,1980 Numerische Verfahren fur die Architekturphotogrammetrie. International Archives of photogrammetry,XXIII (B5):813-823.

محطات الرصد المتكاملة وإستخدامها فى أعمال التسجيل والرفع المعمارى الفوتوجرامترى

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من الشائع إستخدام الفوتوجرامترى فى أعمال التسجيل والرفع المعمارى ويتطلب إستعمال الفوتوجرامترى أجهزة غالية الثمن مثل الكاميرات القياسية والنصف قياسية وأجهزة تجسيم الصور وأجهزة القياس على الصور كماتكون هناك حاجة إلى إستخدام مواد كثيرة كالأفلام والأحماض يضاف إلى هذا الخبرة المتخصصة .ويهدف هذا البحث إلى دراسة إمكانية إستخدام محطات الرصد المتكاملة (Total station) فى أعمال التسجيل والرفع المعمارى لما لها من مميزات كثيرة مثل رخص ثمنها بمقارنتها بالكاميرات القياسية والنصف قياسية وأجهزة الفوتوجرامترى كما أنها لاتحتاج إلى خبرات خاصة فى التشغيل بالإضافة إلى توفرها وشيوعها وإمكانية إستخدامهافى الأغراض المساحية المختلفة . ولإختبار كفائة محطات الرصد فى أعمال التسجيل والرفع المعمارى أجريت تجارب على قصر الجزار باشا بإدارة جامعة المنوفية بمدينة شبين الكوم بإعتبارة أحد المعالم الأثرية الهامة (تم تشيدة عام 1920)حيث أخذت أرصاد بإستخدام محطة الرصد SET 3C كما إلتقطت ثمانى صور للجانبين الشمالى والشرقى من القصر بإستخدام كاميرا التصوير القياسية UMK10/1318 وإستخدم جهاز التكنوكارت- D للقياس على الصور . وتم عمل مقارنة بين نتائج محطة الرصد والفوتوجرامترى التحليلى من حيث الوقت المستغرق للحصول على إحداثيات النقط وعدد النقط الضرورية للتوقيع والمواد والأجهزة المساعدة اللازمة لكل منهما . وقد تبين من هذة الدراسة مدى كفائة إستخدام محطات الرصد فى رفع الواجهات المعمارية ذات الخطوط المستقية كما أوضحت الدراسة مدى إقتصادية محطات الرصد من حيث رخص سعرها مقارنة بالكاميرات القياسية والغير قياسية كما أن الوقت المستغرق فى إنجاز العمل بإستخدامها يقل إلى النصف تقريبا مقارنة بالفوتوجرامترى التحليلى مما يزيد ويشجع من فرص إستخدامها فى أعمال التسجيل والرفع المعمارى وبصفة خاصة فى رفع واجهات المبانى الأثرية ذات الخطوط المستقيمة وبيان التفاصيل المعمارية بدقة تماثل الدقة الناتجةمن الفوتوجرامترى التحليلى ولايعنى هذا الإستغناء عن الفوتوجرامترى التحليلى إذ أن الصور الملتقطة من خلالهاتبقى على مر الزمن كأرشيف يمكن الرجوع إلية فى أى وقت لإستقاء أى معلومات عن الأثر للاستفادةمنها سواء فى أعمال الترميم أو النقل أو إعادة البناء .