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Architectural Photogrammetry for Conservation and Restoration of Historical Building: An Experience With MPS-2 System

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Abstract

Line drawing is an important product of architectural photogrammetry. It is required for the conservation and restoration works. Normally in architectural photogrammetry the line drawings are produced for heritage purposes such as old and historical buildings. There are a few method in producing line drawings. This paper will discuss one of the methods used in a research for producing line drawing by using the Adam Technology MPS-2 System.

1.0 INTRODUCTION

In architectural photogrammetry there are few products that can be used in the conservation and restoration works(Ahmad, 1992; Uren and Thomas,1990). The products are usually in the form of line drawings, photo mosaic and rectified photo. There are methods and techniques available to produce these products. One of the method used to produce line drawings is by using stereoplotter either in the form of analogue or analytical(Uren and Thomas,1990;Ahmad,1992;Uren and Thomas,1992). Line drawings of a project can also be produced by rectifying the photographs and these rectified photographs are digitized using CAD packages such as AutoCAD.

This paper discusses the experience of producing line drawings for architectural photogrammetry using MPS-2 analytical plotter. Also this paper gives the brief report on the assessment of the system for use in architectural photogrammetry (i.e. producing line drawings). In this paper, section two provides the description of the MPS-2 analytical plotter system. Section three and section four describe the process of data acquisition(photographs) and the process of producing the line drawing. Finally, section five gives the summary pertaining to the work done to produce line drawing using the system.

2.0 THE MPS-2 SYSTEM

The MPS-2 is an analytical plotter designed for used with small format metric or non-metric photography (i.e. using 70 mm and 35 mm cameras). It was designed as a low cost solution to the provision of photogrammetric data. Also, it has been designed to reduce the complexity, bulky and cost of photogrammetric hardware and to bypass the requirement for large format photography and trained photogrammetric operators. The system can be maintained by the user and for this reason diagnostic software is provided to assist in checking the instrument's conditions. The cost is quite low compared to most other analytical plotters on the market. With this system, applications such as biostereometrics, industrial measurement, archaeology and architecture can gather accurate information at low cost from small format photography. The system used is shown in figure 1 and comprises the following components

2.1 Hardware

The MPS-2 is small (i.e. 800 x 450 x 350 mm), light and portable. It fits easily on to a desktop. It comprises a binocular microscope which can accommodate photographs from 35 mm and 70 mm cameras. The optical system is good and a zoom facility provides from 8 to 35 times magnification. The diameter of the measuring mark is 25 microns and the movement is controlled by two joysticks-one for X and one for Z. Handwheels and footswictch are also available but these accessories are optional.

The principle use of the MPS-2 is to digitize points on the stereomodel in the form of three-dimensional coordinates. These data are stored in a file. Also, this system can be used to produce a drawing from the stereomodel. Other uses are as follows: (a) calibrate individual cameras and (b) to measure the geometry of the photographs taken with individual camera.

In the MPS-2 the two photographs are mounted in the photo carriers which move in the machine X and Y axes (see figure 2), Two carriages frames are fixed on both sides of the binocular viewer. Each carriage frame holds a Y carriage which then holds an X carriage. This carriage frame forms stepper motor and the carriage can be positioned by fine movements.

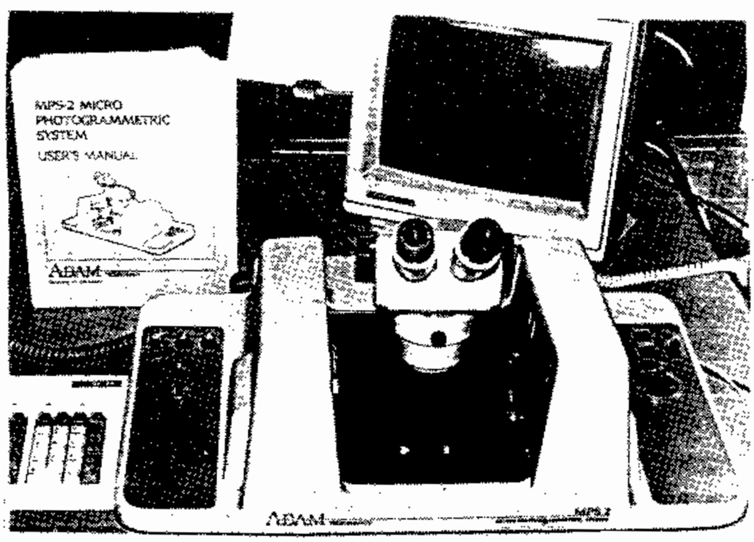


Figure 1 The Adam Technology MPS-2 system

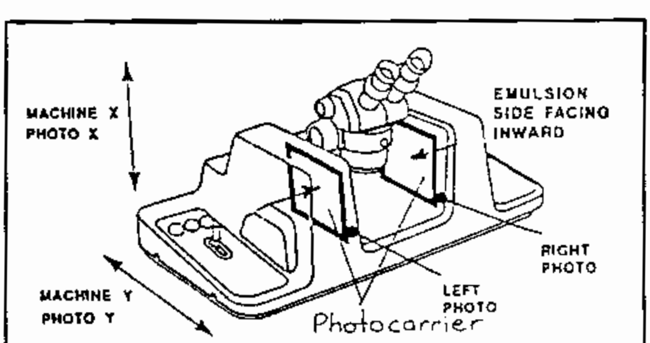


Figure 2 Photocarrier

The MPS-2 is designed as an intelligent computer peripheral that can be interfaced to a variety of host computers. The host computer may be a personal computer, a mini computer or a mainframe and the communication line is the standard RS-232. The systems requires a minimum of 2.5 MB hard disk to run the necessary routines for such tasks as control of output devices and data storage. Also, it requires an operating system such as MS-DOS. In this research, the host computer was a Research Machine Nimbus AX personal computer run on MS-DOS. Hardcopy output can be produced from most graphic printers or plotters by attaching them to the computer. In this work, the line drawing was plotted on a Nicolet Plotter.

2.2 Software

The software is written in FORTRAN. It has been designed for most microcomputers which use the MS-DOS operating system, minicomputers and main frame computers. It can be used with a variety of operating systems. The software is menu driven (i.e. it uses menus whenever possible to allow easy use) which can provides a user friendly device for the operator to operate directly as a sophisticated measurement system. The menus can be selected by moving the up and down arrows keys on the keyboard and pressing the ENTER button. The software is used to create the job file, carry out interior and exterior orientation and digitise points. In creating the job file, the user is allowed to create, delete and edit each item in each record. The user can search for a particular record, examine it and change it, if necessary. For the interior and exterior orientation, the software computes the orientation parameters. In exterior orientation, the stereomodel can be set up either using ground coordinates or distances between points. The results are stored in the job file and the stereomodel can be set up later date by carrying out just the orientation. In digitizing, the software allows data from the stereomodel to be captured using single or continuous modes. The operator has full control of the feature coding of data and new codes can be input during a digitizing session.

Other uses of the software are to calibrate the machine and the camera lens. Also, the software contains a diagnostic program. In machine calibration, precision grid plate are used to calibrate the machine. In camera calibration, the camera constant for lens distortion are determined. The diagnostic program consists of two sections-one section of the program is used to assist in checking the machine and the other section allows the user to check the commands which are sent between the host computer and the machine. This program is used only after the MPS-2 has been shipped to a new destination or after changing the host computer.

Finally, in the software there are programs for communication with the computer, photocarrier control and transformation between photo and ground coordinates. These programs are available immediately when the machine is powered up. However, the calibration, and the transformation tables must be loaded from the computer into random access memory (RAM) before digitising session can commence.

2.3 Connection to a CAD system

The MPS-2 is capable of producing scaled drawing from the photography. In this research it was interfaced with AutoCAD for this purpose. With this interface, AutoCAD treats the stereoplotter as a 3D digitizing tablet and consequently the digitizing and editing processes become more flexible. The drawing of the photographed objects can be plotted on the screen and subsequently plotted on graphic plotter or printer.

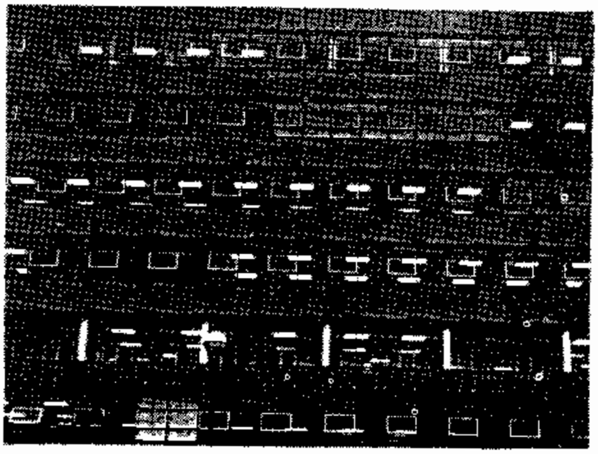
3.0 ACQUISITION OF PHOTOGRAPHS

The photographs used in the MPS-2 can be taken with any camera (i.e. metric or non-metric) with format up to 70 mm. This system also allows any type of photograph with any tilt to be used. In the case of non-metric photography, the camera lens has to be calibrated to determine it lens distortion. A program is provided which allows this to be done. Details of this process are given in section 3.1. In this research, two sets of photographs (i.e. in the form of stereopair) were taken of the test façade. One with a 35 mm Nikon non-metric camera using 35 mm colour slide film. The other with Wild P32 metric camera using colour reversal film. Figure 3 shows a photograph taken using Wild P32 metric camera. The photographs were taken at an approximately base to distance ratio of 1 to 4. The camera axes were tilted upwards and converged to some degree. No attempt was made to determine the precise alignment between the two camera axes at the time of photography.

After the photographs were taken they were developed and colour negatives were produced for the 35 mm Nikon non-metric camera and colour diapositives were produced for the Wild P32 metric camera. Later these photographs were mounted in the MPS-2 to set up the stereomodel.

3.1 Lens Calibration

Generally in photogrammetric work, the camera used has to be calibrated. Metric cameras are calibrated when they are manufactured. For non-metric cameras they need to be calibrated as the distortion in the lens will cause displacements in the image which are unfavourable to precision measurement. The MPS-2 has a program that can calibrate the camera lens. This program uses the self-calibration method. In the calibration, the focal length is determined and the information on the radial and asymmetric lens distortion is provided. In this work the lens of the 35 mm Nikon non-metric camerawas calibrated. The calibration process is as follows. First, the 35 mm Nikon non-metric camera were used to take the photographs of a building with a regular pattern of windows.



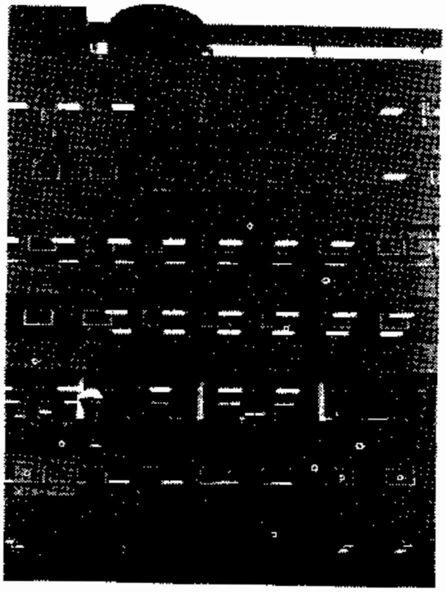


Figure 4 (Left) Lines parallel to longest side; **Figure 5** (Right) Lines parallel to shortest side

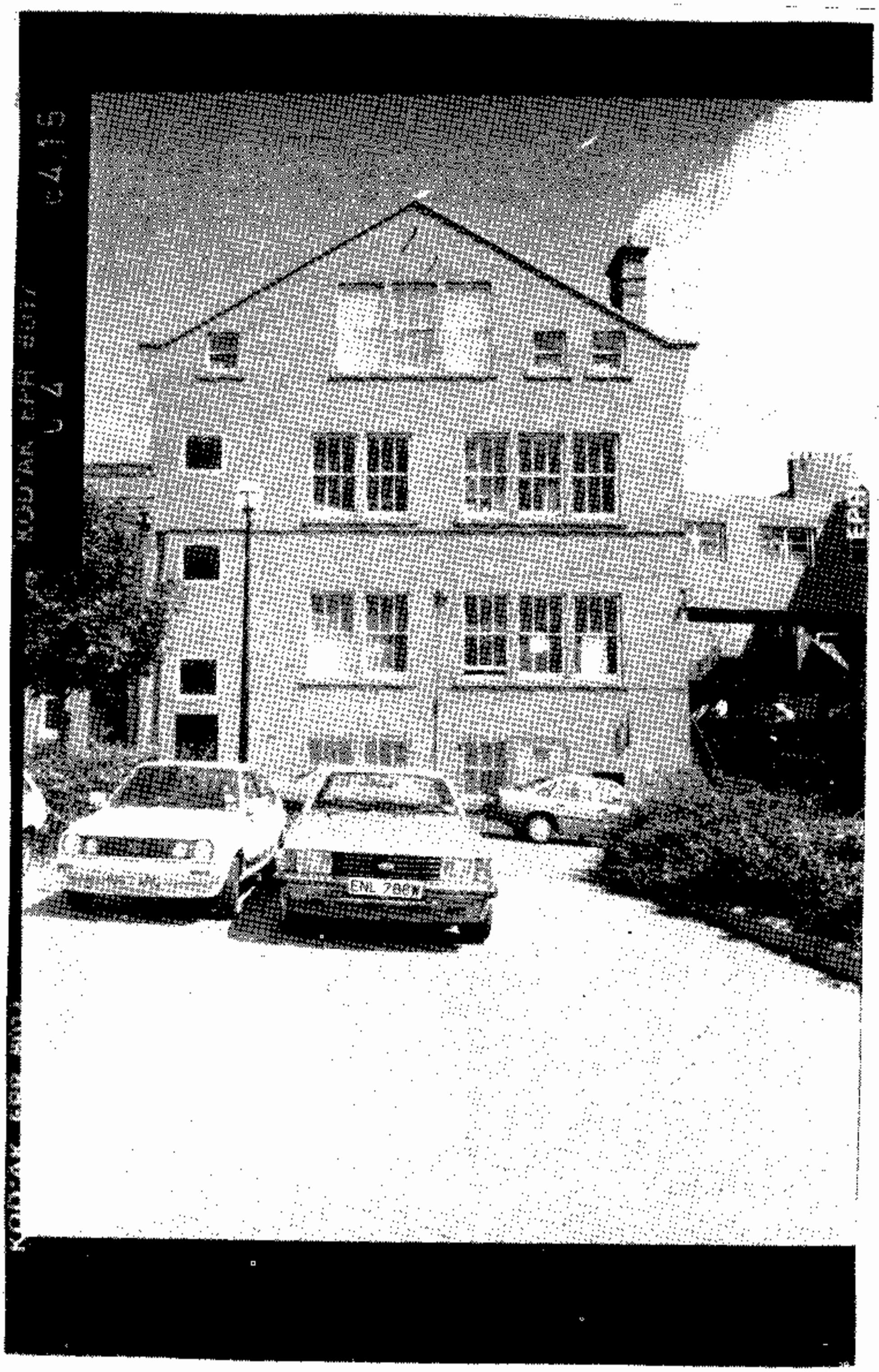


Figure 3 The photographs taken using Wild P32 metric camera

The edges of these windows which are straight lines on the façades should appear as straight lines in the photographs if the lens is distortion-free. Two photographs were taken. One with a set of lines running approximately parallel to the longest side (see figure 4). The other with the lines parallel to the shortest side (see figure 5).

After taking the photographs they were developed and mounted one in the right photocarrier, the other in the left photocarrier. Then the procedure for the lens calibration was carried out.

After all lens were observed, the software computes the lens distortion parameters. These results were input in card 7 (i.e. lens specification) when creating the job file. Figure 6 shows the results of the lens calibration. In these results the original and adjusted focal length were 50 mm and 48.555 mm. The radial and asymmetric distortion of the lens computed for the adjusted focal length of 48.555 mm are listed.

Job: NON_35MM 3-DEC-91 18:59:15
Number of horizontal lines = 6
vertical lines = 7
Total = 13

LENS DISTORTION (for 07 record)

Radial Distortion
R Term : .2891E01
R^3 Term : -.3915E-05
R^5 Term : -.5300E-07
R^7 Term : .3493E-16
X Term : .4305E-04
Y Term : .1214E-04

NOTES:
Lens distortion has been balanced at a point 35 mm
Original Focal Lenght: 50.000 Adjusted Value : 48.555

BALANCED DISTORTION DATA

X	Y	R	Radial Distort.	One Sigma	Decentering Distort.	One Sigma
3.5	3.5	5.0	-.144	.000	.001	.000
7.1	7.1	10.0	-.280	.002	.004	.000
10.6	10.6	15.0	-.380	.006	.010	.001
14.1	14.1	20.0	-.377	.008	.018	.001
17.7	17.7	25.0	-.144	.028	.028	.002
21.2	21.2	30.0	.526	.097	.040	.003
24.7	24.7	35.0	1.940	.253	.055	.004

Figure 6 Results of lens calibration

3.2 Control Points

In this research five control points are selected on a test façade (see figure 7). The control points are enclosed around the test façade. These control points consist of artificial target (i.e. A5) and natural target (i.e. A1 - A4). The coordinate of these control points are determined using theodolite intersection from two ground station 1 and 2 (see figure 8). The Kern E2 total station was used to observe two horizontal and vertical angles from the ground station to the control points on the test façade. The distance from station 1 to station 2 was also observed. Having observed the control points, the coordinate were calculated using the standard intersection formulae. The coordinate were calculated in a standard right handed system of X (easting), Y (northing) and Z (depth).

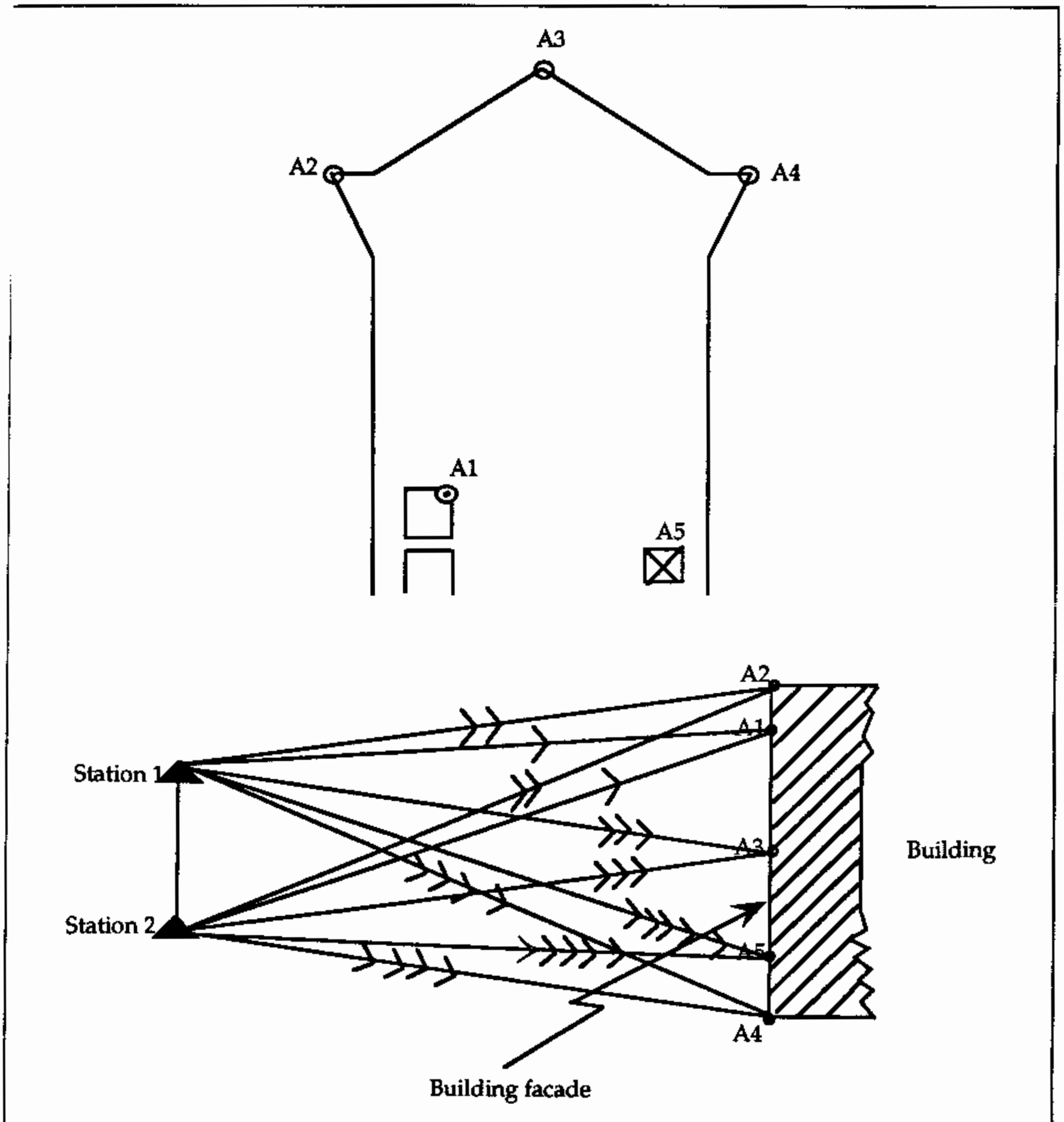


Figure 7 Control points on the test façade (top); **Figure 8** The survey scheme (bottom)

4.0 THE PRODUCTION OF LINE DRAWING

4.1 Setting Up The Stereomodel

Two stereomodels of the test façade were set up. Firstly, the stereomodel from the photographs taken with the Wild P32 metric camera were set up. Secondly, the stereomodel from the photograph taken with the 35 mm Nikon non-metric camera. The process of setting up the stereomodel is the same as in any other analytical plotter (i.e. interior and exterior orientation). Since the software is menu driven and easy to understand, the procedure to set up the stereomodel was found to be straight forward. Before any measurement can be obtained from the photographs stereomodel have to be set up. In this research one stereomodel was set up for each type of photographs to produce line drawing.

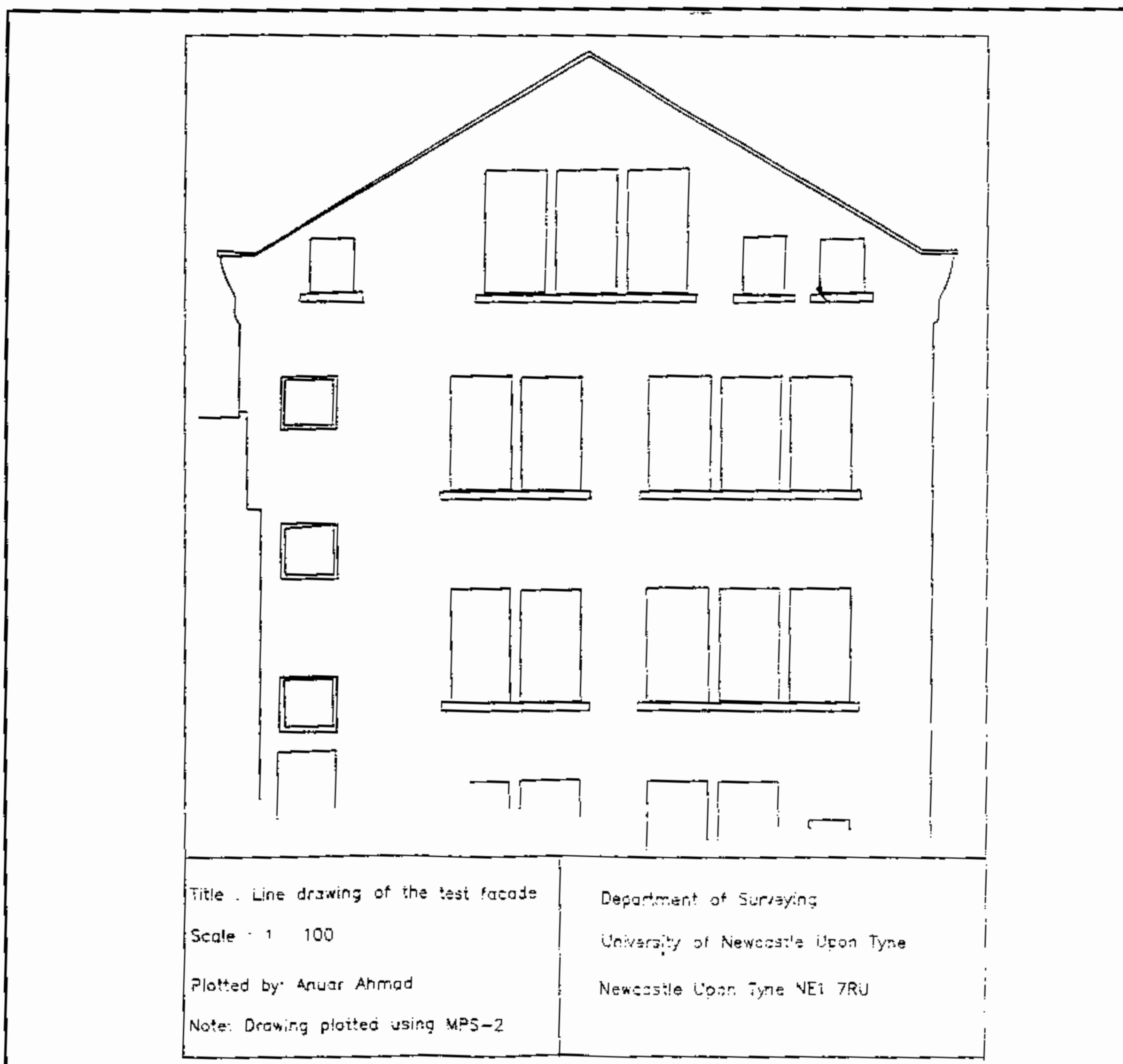


Figure 9 Line drawing of the façade produced from stereomodel of Wild P32 photography

4.2 Plotting

The line drawing of the test façade was produced by dy digitizing the stereomodel from both the Wild P32 metric photography using line mode. The line drawing produced from stereomodel of Wild P32 metric photography was plotted (see figure 9) and no attempt was made to plot the line drawing produced for stetreomodel of 35 mm Nikon non-metric photography. Since the test façade was simple and consists only of straight lines, no symbols were used. The drawing of the test façade was only completed after some considerable time since the measuring mark has to be driven to the correct position and set on the stereomodel in order to record each point. After the drawing was completed, it was edited and enhanced using AutoCAD. Finally, the drawing was plotted using the Nicolet plotter.

5.0 SUMMARY

MPS-2 was found to be a user friendly system. The software which is menu-driven is robust and easy to follow and a very reliable measurement system is provided for small format photography. In other research, the MPS-2 has been used to assess its use in architectural photogrammetry and crack propagation (Uren and Thomas, 1990). The results obtained were satisfactory and encouraging. This means that the MPS-2 can be used as a measuring tool to provide reliable results for applications where small format camera (i.e. metric or non-metric) up to 70 mm format are used.

The manual of the system is straight forward and easy to understand. It is well written and clearly explains all the stages of the procedures to set up the stereomodel, produce the line drawings, calibrate the camera lens etc. Anybody who is familiar with photogrammetry will be able to master the manual within a short time. For non-photogrammetrist it may take some time. However, the "non-photogrammetrist's guide to the MPS-2" written by Uren and Thomas, 1990 can give assistance to the non-photogrammetrist.

This system and its software cost around US$28,000 for a complete system. Today, many professionals such as architects, engineers and others have already used and familiar with AutoCAD as an additional means of gathering data from small format photography. A recent report by Uren and Thomas(1992) stated that majority of the users liked this system. The hardware of the system is extremely reliable and the software have been improved since latest version 2.3

This system is seen as an ideal tool for non-photogrammetrist as a means of providing accurate line drawings and numerical data from both metric and non-metric photography. In addition, they can master the system in a short time and with very little training.

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REFERENCES

Adam Technology MPS-2, 1991, MPS-2 User Manual, Adam Technology, Australia.

Ahmad, A, 1992, An investigation of low cost photogrammetric system using small format photography for use in the recording of buildings, M.Phil Thesis, University of Newcastle Upon Tyne, 163 pages.

Uren, J. and Thomas, P.R., 1992, Adam Technology MPS-2: What the user think, Photogrammetric Record, 14(80):351-355.

Uren, J. and Thomas, P.R., 1990, A new low cost analytical plotter applied to architectural drawings and crack propagation studies, International Archives of Photogrammetry and Remote Sensing, 28(5/1):1576-163

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