CONTACT AREA OF ROMDAS ULTRASONIC MEASUREMENT SYSTEM

TPL Technical Memo - ST3

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by

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1. INTRODUCTION

This is the third Technical Memo describing static testing of the ROMDAS Transverse Profile Logger (TPL) Ultrasonic Measurement System (UMS). The objective of this series of tests was to establish the contact area of the ultrasonic sensor.

The tests were conducted using the PC based software provided with the UMS and not the ROMDAS system.

2. TESTING PROCEDURE

The UMS was installed vertically pointing down at a flat surface. All sensors except the centre sensor were blocked.

A sheet of graph paper was taped to the surface directly below the sensor. The distance of the sensor from the surface was noted. A square object with a height of 96 mm was moved onto the graph paper until the sensor reading changed. The position of the object was marked on the paper. The process was repeated from different positions until a series of chords had been drawn on the paper representing the positions of the object when it was first observed by the UMS. The data were then measured using a ruler to establish a series of co-ordinates.

The measurements were made at three distances from the surface: 305 mm, 412 mm and 473 mm. Annex A contains the data from these measurements.

3. RESULTS

As described in Annex A, the data were normalised so that the minimum x and y values were 10. This facilitated comparing the contact areas from the different heights since they all had the same minimums.

Figure 3.1 shows the contact areas established for each of the three UMS heights. It will be noted that the contact areas are ellipses with the major axis in the direction of travel for the TPL. As would be anticipated, there is a relationship between the contact area and sensor height with the contact area increasing with increasing height.

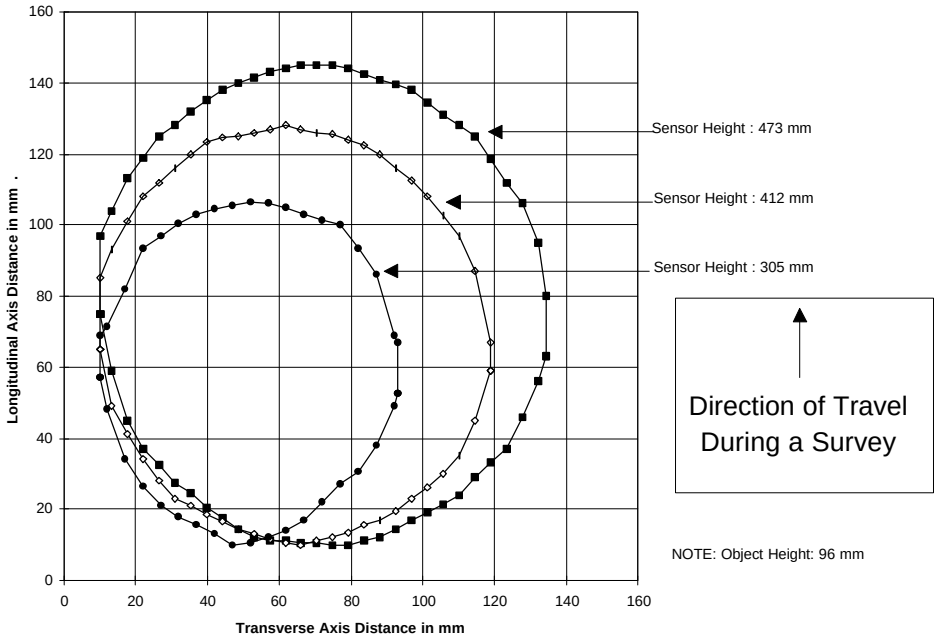

Figure 3.1: UMS Contact Areas at Different Sensor Heights

Table 3.1 shows the lengths and widths of the contact patches under each UMS height. Assuming that the contact area is an ellipse, the contact area in mm^2 was calculated[1] and the resulting value is given in Table 3.1.

Table 3.1
Measurements of Contact Areas

UMS Height	Length of Contact Patch (mm)	Width of Contact Patch (mm)	Contact Area (mm^2)
305 mm	96.5	83.0	20.65
412 mm	118.0	108.9	24.50
473 mm	135.0	124.3	27.86

There is a strong linear trend between these values and UMS height. This is illustrated in Figure 3.2.

The data in Table 3.1 can be used to calculate the beam dispersion. Using the geometry illustrated in Figure 4.3, the tan of the angle of the beam at each of the three contact areas (A, B and C) can be calculated. Since there are two dimensions to the contact area, the dispersion can be calculated for both dimensions. Given that the ultrasonic sensors are circular, the elliptical contact areas indicate that there should be different angles in the two dimensions.

[1] The area of an ellipse is calculated using the equation: AREA = π (L/2) (W/2).

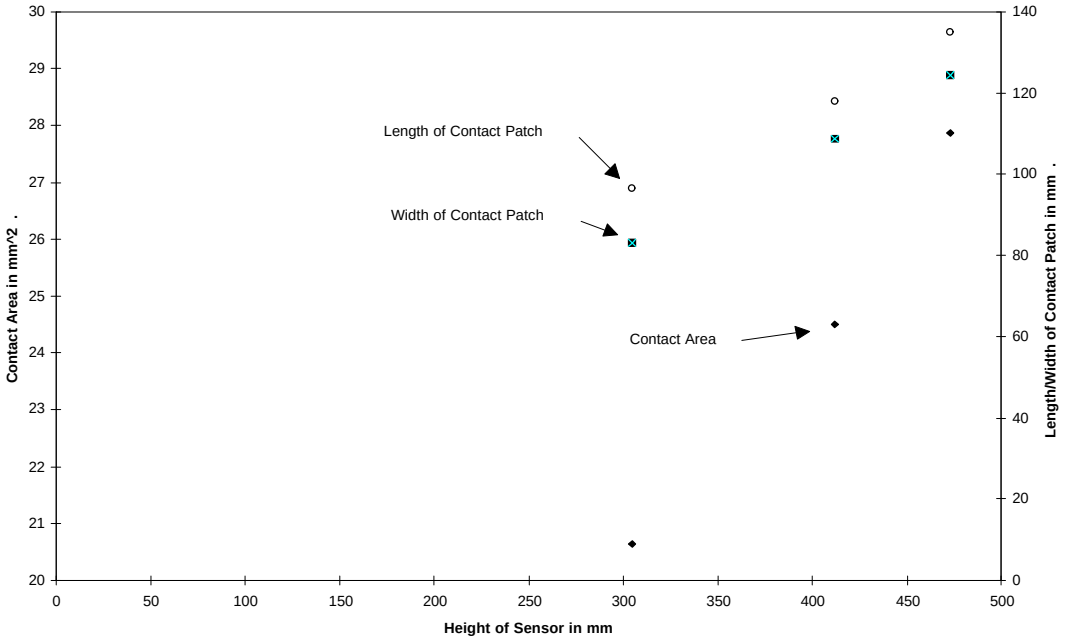

Figure 3.2: Contact Area Measurements as Function of Sensor Height

Table 3.2 presents the calculated angles of dispersion. It can be seen that the data for the lenght-wise measurements has a great deal of scatter while the data for the width-wise measurements is very consistent with the angle being approximately 7 degrees.

Table 3.2
Angle of Dispersion

Contact Areas	Angle of Dispersion in Degrees	
	Using Length	Using Width
305 - 412 mm	5.74	6.90
412 - 473 mm	7.93	7.19
305 - 473 mm	6.54	7.01
Average	6.74	7.03

It was not possible to establish the reason why the length-wise measurements had so much variation.

4. CONCLUSIONS

These tests have shown that the UMS sensors have the following attributes:

- the contact area is an ellipse with the major axis in the direction of travel;
- there is a relationship between the ellipse area and the sensor height;
- at the expected operating heights of 300 - 400 mm the contact area will be on the order of 20.5 - 24.5 mm^2;

- the beam has a dispersion angle of approximately 7 degrees along the minor axis (width-wise). It was not possible to accurately establish the angle for the major axis.

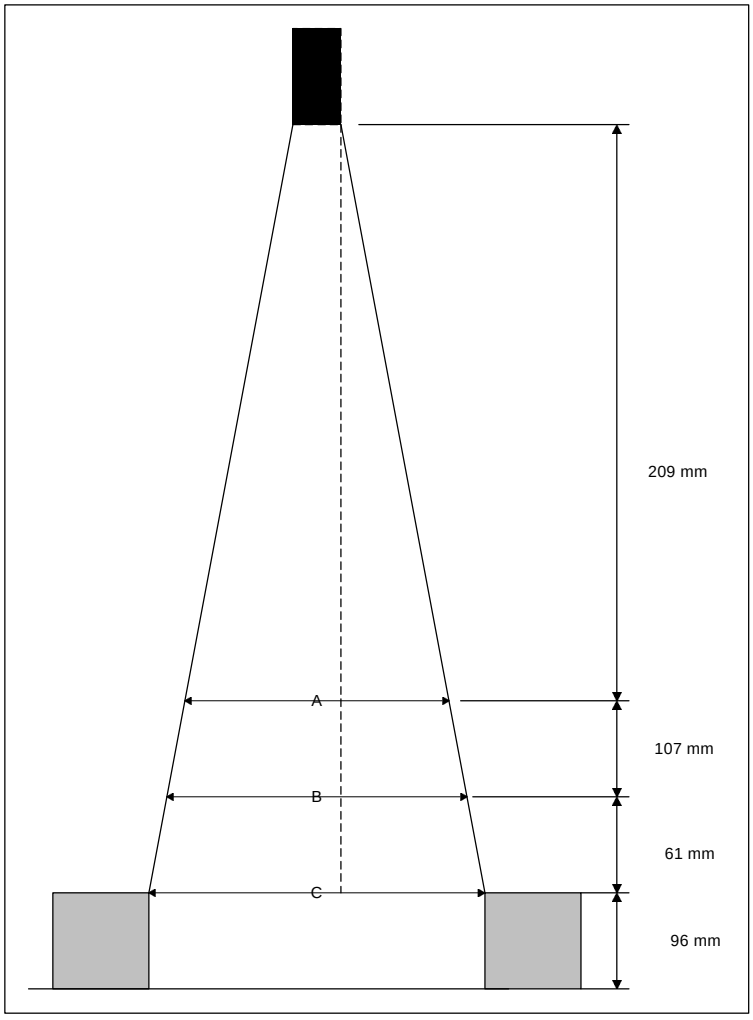

Figure 4.3: Geometry for Calculating Beam Dispersion Angle

ANNEX A
TESTING DATA

The data consisted of a series of chords on graph paper which roughly formed an ellipse. The data were reduced by firstly scaling the two vertical distances at points along the x axis (y1 and y2). After completing the 305 mm test the graph paper was altered so there were different horizontal scales for the next two tests.

Having established a series of (x, y) coordinates, the data were normalised to the same minimum x and y values. This was done to facilitate comparing the contact areas. The steps involved were:

- the x values were adjusted arithmetically so that minimum x value in each test was 10.
- the y values were adjusted arithmetically so that the minimum y value in each test was 10.

Table A.1 presents the final normalised data.

Table A.1
Normalised Data

H = 305 mm			H = 412 mm			H = 473 mm		
x	y1	y2	x	y1	y2	x	y1	y2
10.0	57.0	69.0	10.0	65.0	85.0	10.0	75.0	97.0
12.0	48.0	71.5	13.3	49.0	93.0	13.3	59.0	104.0
17.0	34.0	82.0	17.7	41.0	101.0	17.7	45.0	113.0
22.0	26.5	93.5	22.1	34.0	108.0	22.1	37.0	119.0
27.0	21.0	97.0	26.5	28.0	112.0	26.5	32.5	125.0
32.0	18.0	100.5	30.9	23.0	116.0	30.9	27.5	128.0
37.0	15.5	103.0	35.3	21.0	120.0	35.3	24.5	132.0
42.0	13.0	104.5	39.7	18.5	123.5	39.7	20.5	135.0
47.0	10.0	105.5	44.1	16.5	124.5	44.1	17.5	138.0
52.0	10.5	106.5	48.5	14.5	125.0	48.5	14.5	140.0
57.0	12.0	106.0	52.9	13.0	126.0	52.9	12.0	141.5
62.0	14.0	105.0	57.3	11.5	127.0	57.3	11.0	143.0
67.0	17.0	103.0	61.7	10.5	128.0	61.7	11.0	144.0
72.0	22.0	101.5	66.1	10.0	127.0	66.1	10.5	145.0
77.0	27.0	100.0	70.5	11.0	126.0	70.5	10.5	145.0
82.0	30.5	93.5	74.9	12.0	125.5	74.9	10.0	145.0
87.0	38.0	86.0	79.3	13.5	124.0	79.3	10.0	144.0
92.0	49.0	69.0	83.7	15.5	122.5	83.7	11.0	142.5
93.0	52.5	67.0	88.1	17.0	120.0	88.1	12.0	141.0
			92.5	19.5	116.0	92.5	14.5	139.5
			96.9	23.0	112.5	96.9	17.0	138.0
			101.3	26.0	108.0	101.3	19.0	134.5
			105.7	30.0	102.5	105.7	21.5	131.0
			110.1	35.0	97.0	110.1	24.0	128.0
			114.5	45.0	87.0	114.5	29.0	125.0
			118.9	59.0	67.0	118.9	33.0	118.5
						123.3	37.0	112.0
						127.7	46.0	106.0
						132.1	56.0	95.0
						134.3	63.0	80.0