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Covermeter for identifying cover depth and rebar diameter in high strength concrete

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ABSTRACT

Learning about the reinforcement position in concrete components is essential as they are a very important component of concrete structures provided to offer ductility and tensile strength to the concrete. In many field applications, it becomes essential to know the depth of cover, identify location of rebars and their diameter. This information becomes essential directly or indirectly in the field. Ascertaining the cover depth is important to implement durability standards to the structure under construction. Knowing the diameter of the bar and their location is essential to understand the bar spacing and their placement, in existing structures where drawing may not be available. Also, in cases where concrete core extracts are to be taken the identification of the rebar locations becomes essential to avoid cutting of the reinforcement bars. The present work focuses on identifying the capabilities and the limitations of using covermeter in high strength concrete.

Keyword: Rebar locator, cover meter, rebar diameter, concrete, reinforcement.

1. Introduction

Concrete is provided with reinforcement in almost all structures. Locating the rebars and its diameter are important requirements in many field situations. Also, determining the cover depths is important to assess the durability aspects followed in a construction site. To determine these aspects it becomes necessary to apply non-destructive testing methods. Hence, rebar locators or the covermeter is being used in the site. Also, locating rebar is important to determine the locations for concrete core cutting. They can also be used to locate the bars and their spacing in cases where drawings are not available for old structures. These details may be required for evaluation of the existing structure. Similarly, durability aspects are sometimes given lesser importance. Providing the correct cover depth as per the codal recommendations ensures minimum corrosion of the reinforcement bars. Evaluating the cover is hence important to ensure longer life for the structure. The quality engineer accesses the cover keeping in mind the durability aspect and the environmental conditions of the structure.

Using high strength concrete is the order of the day. High strength concrete has higher density and hence the cover meter or rebar locators may not function in the same way as they do in normal concrete. Hence, the present work focuses on accessing the cover meter to detect rebars of various diameters placed at different depths. The limits and bounds of the applicability of the equipment is being accessed under laboratory conditions.

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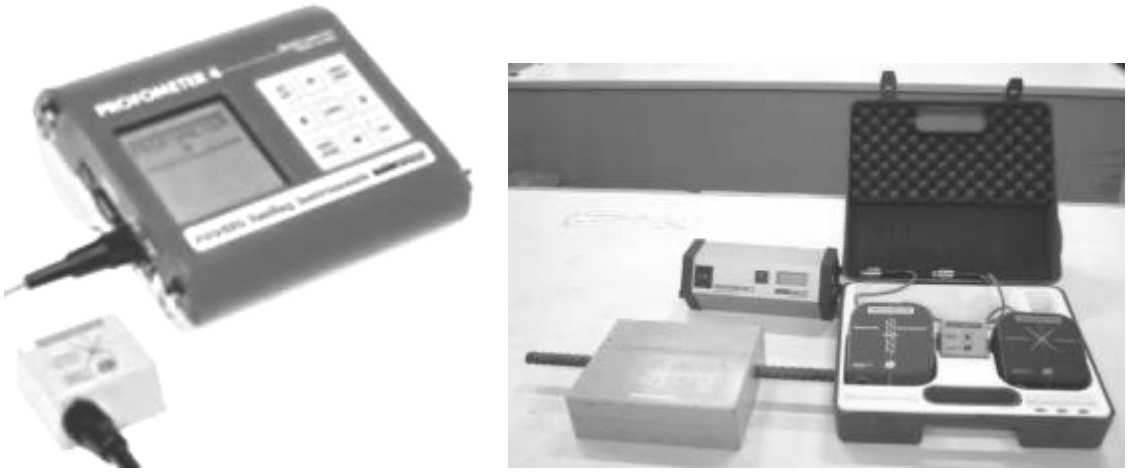
A detailed work by Motazed (1985) on interpretation of magnetic sensing for detection of rebars provides lots of insight into this area of rebar detection in concrete structures. Alldred (1995) has worked on the improving the rebar detection using a covermeter. The review work by McCann and Forde (2001) is very useful in understanding the application of non-destructive testing methods for identification of defects and detection of rebars.

2. Covermeter, Rebar locator and Rebar diameter identifier

Covermeter is a device used to determine the precise concrete cover depth and to pinpoint the exact location of the rebars in the concrete. The cover depth of the concrete has a major impact on those processes that lead to corrosion of the rebars. Hitting a rebar while boring into reinforced concrete can damage the drilling instrument or even weaken the concrete structure. Trying to avoid rebars, however, can be a tedious and difficult process. Therefore, it is vital to know the cover depth and precise location of the rebars before starting the maintenance work. Since, the eddy-current principle with pulse-induction is the most economical solution, most cover meters are based on this principle. In the case of double layer arrangements of the rebars it is suggested to start the location with the first layer. If the layers are too close to each other, it is likely to be impossible to locate the bars of the second layer.

For precise determination of the bar diameter it is important to verify that there are no unnoticed influences that could falsify the result. Therefore it is recommended to select a place on the structure where there is sufficient spacing between the rebars. It must also kept in mind that the cover depth of the concrete influences the accuracy of the cover meters. The accuracy of the cover meters decreases with the depth of the concrete cover. In the present work, the Proceq Profometer 4 has been used (as shown in figure 1). The Profometer 4 cover meter allows the detection of rebars, measurement of concrete cover depth and rebar diameter. The covermeter offers optical as well as acoustic locating aids. Locating the rebars with the cover meter helps to avoid them when drilling holes.



(a) Cover meter (b) Probes and accessories

Figure 1: Covermeter (Proceq Profometer)

3. Experimental studies

The present work focused on identifying rebars, their diameter and the clear cover above them in high strength concrete. Identifying the rebar details is essential in field conditions. In

the cases of core extraction, identifying the rebar location is essential to avoid cutting of the main rebars. Also, these days with the increased usage of high strength concrete in the construction industry, it becomes important to calibrate equipments in the laboratory before being used in the field conditions.

3.1 Specimen details

For the experimental investigation, ten concrete blocks were cast with high strength concrete. The 28 days cube strength of concrete was 71.3 MPa. The size of all the concrete blocks is 400 × 400 × 250 mm. Steel reinforcement bars of five of the commonly available bar diameters were selected in such a way they cover the wide range bars that are commonly used in residential structures. Bars of diameter 32mm, 25mm, 20mm, 16mm, and 12mm have been chosen for casting the blocks. Each block of concrete was cast with one bar alone, centre of which was placed either at 50mm or 100mm from the top, for the full width of the specimen. To place the bars in a constant position during concreting and vibrating, moulds were made with a hole on either side. The holes were made with their centres at 50mm or 100mm from the top surface. Separate moulds were cast for each of the ten specimens. The diameter of the hole and its position from the top in each mould would hence match with the specimen planned to be cast in that mould. Figure 2 shows a typical specimen and Figure 3 shows the side elevations indicating the locations of the rebar. Table 1 gives the naming of the specimens.

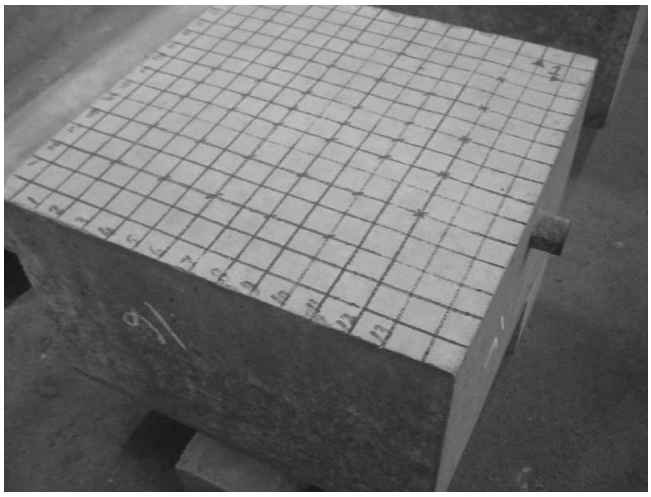
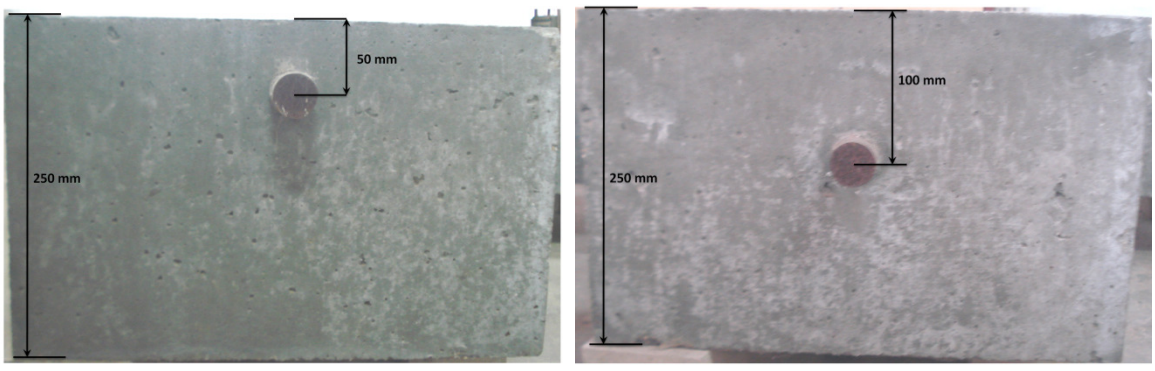


Figure 2: A Typical specimen used for the identification of the reinforcement bars (32mm ϕ at 50mm from top)



(a) Bar at 50mm (b) Bar at 100mm

Figure 3: Specimen side showing the position of rebar

Table 1: Specimens numbering details

Specimen number	Diameter of bar (mm)	Actual location of bar centre from top surface (mm)
1	32	50
2	32	100
3	25	50
4	25	100
5	20	50
6	20	100
7	16	50
8	16	100
9	12	50
10	12	100

4. Results and discussion

4.1 Results obtained using small cover thickness probe

The small probe is generally used for depths below 70mm. The probe is used to identify the clear cover above the rebars of different diameters. Clear covers to be identified range from 34mm to 94mm. The covers are grouped into two categories as short range covers and deeper cover thickness. While the first category (Cover-1) includes the clear covers in the range 34mm to 44mm, the second category (Cover-2) includes the five specimens whose clear cover range from 84mm to 94mm. The specimen details, the actual and detected cover thickness and the error in detecting them are listed in Table 2.

Table 2: Clear cover identified using small probe

Specimen number	Diameter of bar	Actual location of bar centre from top surface	Small probe		
			Detected clear cover	Actual clear cover	Error in detection
	(mm)	(mm)	(mm)	(mm)	(%)
1	32	50	32	34	5.88%
5	25	50	34	37.5	9.33%
9	20	50	37	40	7.50%
4	16	50	41	42	2.38%
8	12	50	51	44	-15.91%
3	32	100	70	84	16.67%
7	25	100	64	87.5	26.86%
2	20	100	58	90	35.56%
6	16	100	66	92	28.26%
10	12	100	70	94	25.53%

From the results, it can be observed that the small cover thickness probe in the covermeter is effective in detecting the clear cover thickness for category 1 (Cover-1), as has been claimed

by the manufacturer. However even in this category, the error in detection of the clear cover for 12mm rebar is high, of the order of 15.91%. As claimed by the manufacturers, the smaller probe is ineffective in detecting clear covers larger than 70mm. It can be observed from Table 2 that the errors range from 16.67 to 35.56 %.

4.2 Results obtained using the large cover thickness probe

The large cover thickness probe is generally used for depths greater 70mm. Here, the probe is used to identify the clear cover above the rebars of different diameters. Clear covers to be identified range from 34mm to 94mm. The specimen details, the actual and detected cover thickness and the error in detecting them are listed in Table 3. From the results, it can be observed that the large cover thickness probe in the covermeter is effective in detecting the clear cover thickness for category 2 (Cover-2), as has been recommended by the manufacturer. It can be observed that the probe is able to identify the clear cover of Cover-2 category specimens atleast with some error. Though the errors are not very small, the ability of the probe to detect covers greater than 70mm is demonstrated from this study. Also the probe is able to detect cover for smaller range cover thicknesses. However, the error in detection is much higher than that obtained using smaller probe. Hence, it can be concluded that the small probe be used for smaller cover depths and the large probe be used for larger cover depths. Other than these observations, it also becomes essential to note that the effectiveness of the large probe to detect cover thickness over 12mm bars is poor irrespective of the cover depth. This observation leads to an important question regarding the effectiveness of the equipment to detect rebars of diameter 10mm or lesser. The reinforcement used in slabs in residential buildings or low rise buildings are of diameter 10mm or 12mm. In these cases, it will become very difficult to use cover meter to obtain reliable results on cover thickness.

Table 3: Clear cover identified using large probe

Specimen number	Diameter of bar	Actual location of bar centre from top surface	Large probe		
			Detected clear cover	Actual clear cover	Error in detection
	(mm)	(mm)	(mm)	(mm)	(%)
1	32	50	26	34	23.53%
5	25	50	30	37.5	20.00%
9	20	50	35	40	12.50%
4	16	50	39	42	7.14%
8	12	50	54	44	-22.73%
3	32	100	70	84	16.67%
7	25	100	74	87.5	15.43%
2	20	100	82	90	8.89%
6	16	100	90	92	2.17%
10	12	100	116	94	-23.40%

4.3 Identifying bar diameter

Detecting the rebar diameter is important to evaluate the structure in cases where drawings are not available. The covermeter provides the option of probing the diameter using a diameter probe. The Table 4 shows the actual diameter, detected diameter and the errors in detecting these values.

Table 4: Detecting the rebar diameter using diameter probe

Specimen number	Diameter of bar	Actual location of bar centre from top surface	Diameter probe		
			Detected Diameter	Actual Diameter	Error in detection
	(mm)	(mm)	(mm)	(mm)	(%)
1	32	50	32.4	32	1.25%
5	25	50	25.6	25	2.40%
9	20	50	27	20	35.00%
4	16	50	17.9	16	11.88%
8	12	50	Cover too thick!*	12	100.00%
3	32	100	Cover too thick!*	32	100.00%
7	25	100	Cover too thick!*	25	100.00%
2	20	100	Cover too thick!*	20	100.00%
6	16	100	Cover too thick!*	16	100.00%
10	12	100	Cover too thick!*	12	100.00%

* - Error message displayed by equipment

From the Table 4, it can be observed that the diameter probe is effective in detecting rebar diameters between 32mm and 16mm for a cover depth ranging from 34mm to 42mm. Above this cover depth (that is even for 44mm) the equipment gives a warning ("Cover too thick!") while detecting a 12mm rebar. It is not understood whether this warning is due to larger cover thickness or due to smaller bar diameter. In case of the specimens in second category with cover thickness ranging from 84mm to 94mm, the equipment was ineffective in detecting the rebar diameters. From the study, it is observed that the covermeter is effective in detecting rebar diameter in shallow cover depths only and that too for rebars of diameter larger than 12mm.

4.4 Bar diameter detection with increased cover

Then the diameter probe has been used to study its effectiveness in detecting rebar diameter with increasing cover depths. For this study, the specimen 1 with a 32mm bar placed at 34mm below the top surface has been chosen. The covermeter detected the bar diameter effectively with a small error of about 1.25%. With increased cover thickness, it has been observed that the error in identifying the bar diameter increases. For cover greater than 70mm, the instrument displays the warning message that the "cover is too thick". The error in detecting the rebar diameter with increasing cover depths is shown in Figure 4. Thus, it has been observed that the bar diameter can be identified very efficiently for a cover depth of about 30-35mm and for further increase in the cover depth the reliability on identification is

poor and the equipment ceases to perform for cover greater than 70mm in high strength concrete.

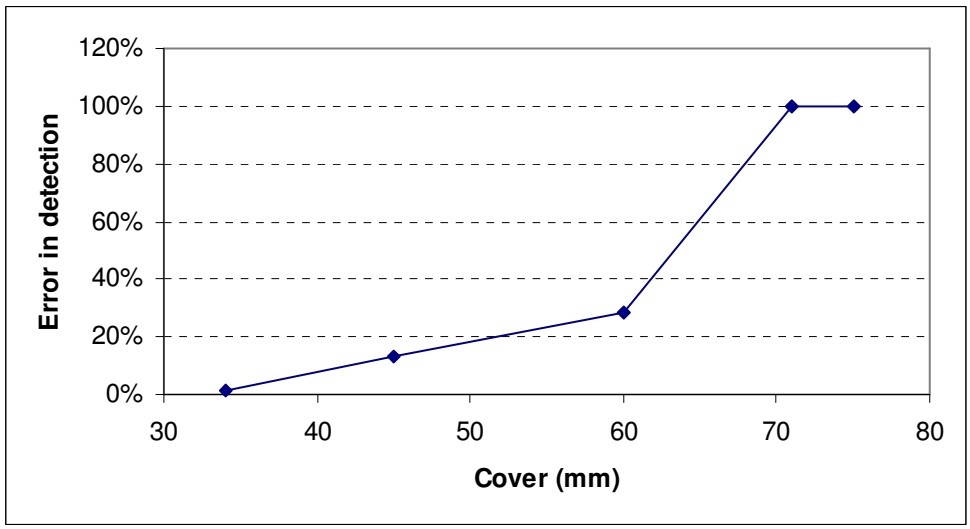


Figure 4: Error in detecting rebar diameter with increasing cover depths

5. Conclusions

Even though the manufacturers have greater claims on their equipment, an assessment by the end user on the limiting values, the pros and cons of the technology is essential to have better confidence. Also, such studies are essential to the field engineers to understand the reliability of the results they obtain using this technology.
It shall be noted that these results are obtained under laboratory conditions. Hence, the results will be more unreliable in field conditions.

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