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Study of Strain in Elasto-Plastic Material by X-Ray Diffraction Technique

Prof. M. D. Mehare[1], Prof. N. N. Bhaiswar[2], Prof. K. S. Shelke[3]

Applied Physics Department, Priyadarshini Indira Gandhi College of Engineering , Nagpur, Maharashtra,
Department of Mechanical Engineering, Priyadarshini Indira Gandhi College of Engineering, Nagpur, Maharashtra
Department of Mechanical Engineering, Priyadarshini Indira Gandhi College of Engineering, Nagpur,

ABSTRACT: *This research paper highlights the applicability of X-ray diffraction method to evaluate the strain in elasto-plastic material like concrete.The aim of this study is to explore the possibilities of X-Ray diffraction technique in determining strain within the body of any elastoplastic material like concrete.This paper consolidates the calculations of body strain of highly unpredictable elasto-plastic material like concrete.*

Keywords: *Elastoplastic material, X-ray diffraction, strain.*

I. INTRODUCTION

In metals strain is very easily calculated evaluating change in length and original length but case in plastic materials is different.To study strain within body in elastoplastic material is cumbersome job.Rather instrumentation can not be applied in case of unpredictable material like concrete which is heterogeneous and elastoplastic.This paper aims to study the scope of implementation of X-Ray diffraction technique to evaluate strain in concrete.In this paper concrete grade M.20 is taken for X-ray diffraction and 5 grams powder is taken. In this paper 5 grams of two powder samples of 15cm x 15cm x 15cm cubes in unstressed condition (cube not subjected to failure load in compressive testing machine) and stressed condition (cube subjected to failure load in compressive testing machine) are taken and X-ray diffraction is carried out for M-20 grade normal concrete.

II. X-RAY DIFFRACTION GRAPH AND PEAK LIST

2.1 M.20 Unstressed sample:

Anchor Scan Parameters

Dataset Name:	M-20-Unstressed
File name:	H:\X'Pert Data\Oct 13\15th Oct\M-20-Unstressed.xrdml
Comment:	Configuration=Flat stage, Owner=User-1, Creation date=1/15/2009 8:55:18 AM Goniometer=PW3050/60 (Theta/Theta); Minimum step size 2Theta:0.001; Minimum step size Omega:0.001 Sample stage=PW3071/xx Bracket Diffractometer system=XPERT-PRO Measurement program=xrd program, Owner=User-1, Creation date=1/15/2009 9:49:56 AM
Measurement Date / Time:	10/15/2013 4:51:41 PM
Operator:	ABC
Raw Data Origin:	XRD measurement (*.XRDML)
Scan Axis:	Gonio
Start Position [°2Th.]:	5.0044
End Position [°2Th.]:	99.9834
Step Size [°2Th.]:	0.0170
Scan Step Time [s]:	5.1682
Scan Type:	Continuous
PSD Mode:	Scanning
PSD Length [°2Th.]:	2.12
Offset [°2Th.]:	0.0000
Divergence Slit Type:	Fixed
Divergence Slit Size [°]:	1.0000
Specimen Length [mm]:	10.00
Measurement Temperature [°C]:	25.00
Anode Material:	Cu
K-Alpha1 [Å]:	1.54060
K-Alpha2 [Å]:	1.54443
K-Beta [Å]:	1.39225
K-A2 / K-A1 Ratio:	0.50000
Generator Settings:	30 mA, 40 kV
Diffractometer Type:	00000000083002110
Diffractometer Number:	0
Goniometer Radius [mm]:	240.00
Dist. Focus-Diverg. Slit [mm]:	100.00
Incident Beam Monochromator:	No
Spinning:	No

2.2 Peak List:

Peak List

Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel.Int. [%]
17.9636	93.13	0.1004	4.93809	1.28
20.7871	977.63	0.1171	4.27329	13.48
21.9722	68.26	0.1338	4.04542	0.94
23.0589	122.09	0.2007	3.85716	1.68
24.0698	30.40	0.4015	3.69741	0.42
25.5100	42.42	0.4015	3.49183	0.58
26.5668	7254.31	0.0836	3.35529	100.00
27.3660	447.14	0.0669	3.25909	6.16
29.3672	1225.63	0.1840	3.04140	16.90
30.6241	289.35	0.0669	2.91938	3.99
34.0066	107.39	0.1338	2.63634	1.48
35.9602	107.78	0.2007	2.49747	1.49
36.4285	620.80	0.0669	2.46643	8.56
38.4591	111.17	0.2007	2.34076	1.53
39.3852	528.84	0.0669	2.28783	7.29
40.2112	223.71	0.0502	2.24272	3.08
41.7507	53.73	0.2007	2.16351	0.74
42.3803	276.38	0.0669	2.13282	3.81
43.1493	150.37	0.1673	2.09657	2.07
44.6551	768.35	0.1004	2.02931	10.59
45.7123	150.46	0.0669	1.98481	2.07
47.0766	105.43	0.2007	1.93042	1.45
47.4593	152.88	0.2007	1.91575	2.11
48.4924	136.11	0.2342	1.87732	1.88
50.0845	459.73	0.1020	1.81980	6.34
50.2257	241.77	0.0816	1.81953	3.33
54.8119	238.43	0.0612	1.67350	3.29
54.9546	133.35	0.0612	1.67364	1.84
55.2775	71.06	0.1224	1.66050	0.98
57.4158	67.76	0.3264	1.60364	0.93
58.6429	67.35	0.1224	1.57297	0.93
59.8891	510.83	0.0612	1.54319	7.04
60.0555	254.26	0.0816	1.54313	3.50
60.8803	37.23	0.4896	1.52041	0.51
65.1594	70.85	0.3264	1.43053	0.98
67.6785	183.52	0.1020	1.38328	2.53
68.0779	491.40	0.0816	1.37613	6.77
68.2646	491.03	0.0816	1.37282	6.77
68.4529	132.28	0.0612	1.37291	1.82
72.9589	19.23	1.3056	1.29563	0.27
75.6059	120.23	0.1020	1.25671	1.66
75.8218	92.10	0.0816	1.25679	1.27
78.1617	50.55	0.4080	1.22189	0.70
79.8031	136.78	0.0816	1.20083	1.89
80.0235	76.20	0.1224	1.19808	1.05
81.1619	92.59	0.0816	1.18412	1.28
81.4181	84.21	0.1632	1.18105	1.16
83.8108	80.54	0.1224	1.15331	1.11
85.0514	15.19	0.4896	1.13963	0.21
90.8055	88.57	0.1020	1.08179	1.22
92.8682	17.51	0.4896	1.06309	0.24
94.6207	68.02	0.1224	1.04797	0.94
95.0671	46.71	0.2448	1.04423	0.64
96.2292	54.63	0.1224	1.03468	0.75

2.3 Graphics M.20 stressed sample:

Anchor Scan Parameters

Dataset Name:	M-20-stressed
File name:	H:\X'Pert Data\Oct 13\15th Oct\M-20-stressed.xrdml
Comment:	Configuration=Flat stage, Owner=User-1, Creation date=1/15/2009 8:55:18 AM Goniometer=PW3050/60 (Theta/Theta); Minimum step size 2Theta:0.001; Minimum step size Omega:0.001 Sample stage=PW3071/xx Bracket Diffractometer system=XPERT-PRO Measurement program=xrd program, Owner=User-1, Creation date=1/15/2009 9:49:56 AM
Measurement Date / Time:	10/15/2013 4:40:12 PM
Operator:	ABC
Raw Data Origin:	XRD measurement (*.XRDML)
Scan Axis:	Gonio
Start Position [°2Th.]:	5.0044
End Position [°2Th.]:	99.9834
Step Size [°2Th.]:	0.0170
Scan Step Time [s]:	5.1682
Scan Type:	Continuous
PSD Mode:	Scanning
PSD Length [°2Th.]:	2.12
Offset [°2Th.]:	0.0000
Divergence Slit Type:	Fixed
Divergence Slit Size [°]:	1.0000
Specimen Length [mm]:	10.00
Measurement Temperature [°C]:	25.00
Anode Material:	Cu
K-Alpha1 [Å]:	1.54060
K-Alpha2 [Å]:	1.54443
K-Beta [Å]:	1.39225
K-A2 / K-A1 Ratio:	0.50000
Generator Settings:	30 mA, 40 kV
Diffractometer Type:	0000000083002110
Diffractometer Number:	0
Goniometer Radius [mm]:	240.00
Dist. Focus-Diverg. Slit [mm]:	100.00
Incident Beam Monochromator:	No
Spinning:	No

Peak List

Pos. [°2Th.]	Height [cts]	FWHM [°2Th.]	d-spacing [Å]	Rel. Int. [%]
11.5645	21.41	1.0706	7.65214	0.36
13.7225	49.45	0.2007	6.45322	0.82
18.1827	153.29	0.1004	4.87908	2.54
20.9784	837.63	0.1004	4.23476	13.89
23.2095	126.77	0.1338	3.83248	2.10
23.7271	61.27	0.1004	3.75003	1.02
24.4821	86.25	0.1004	3.63606	1.43
25.7221	45.45	0.3346	3.46352	0.75
26.7827	6030.56	0.0669	3.32873	100.00
27.1453	260.06	0.0502	3.28508	4.31
27.5339	1544.98	0.0669	3.23960	25.62
28.0551	510.18	0.0836	3.18058	8.46
29.5754	1355.01	0.0836	3.02046	22.47
30.8945	256.26	0.1004	2.89444	4.25
32.6720	79.80	0.1004	2.74091	1.32
34.2250	190.58	0.0669	2.62002	3.16
36.1688	133.52	0.2342	2.48355	2.21
36.6768	334.42	0.0669	2.45031	5.55
39.6046	363.88	0.0669	2.27565	6.03
40.4476	212.38	0.0502	2.23015	3.52
41.9522	140.39	0.0669	2.15358	2.33
50.4180	379.00	0.0612	1.81304	6.28
50.9634	80.32	0.3264	1.79047	1.33
55.0168	285.29	0.0816	1.66775	4.73
55.1672	155.13	0.0612	1.66769	2.57
55.4590	62.45	0.1224	1.65550	1.04
57.6249	73.26	0.3264	1.59832	1.21
58.8522	47.80	0.3264	1.56788	0.79
60.1090	408.41	0.0816	1.53806	6.77
60.2722	197.06	0.0816	1.53810	3.27
64.2298	42.01	0.4896	1.44897	0.70
67.8861	238.90	0.0816	1.37955	3.96
68.0793	134.02	0.1224	1.37611	2.22
68.2899	404.63	0.0612	1.37238	6.71
68.4788	231.19	0.0816	1.36905	3.83
73.0223	19.84	1.3056	1.29466	0.33
73.6183	76.78	0.0816	1.28565	1.27
75.0889	83.30	0.1224	1.26408	1.38
75.7790	78.44	0.0816	1.25427	1.30
77.7923	56.48	0.1632	1.22677	0.94
79.3161	90.90	0.1224	1.20698	1.51
80.0398	167.48	0.0816	1.19788	2.78
80.1969	93.72	0.3264	1.19593	1.55
81.3277	98.36	0.0612	1.18213	1.63
81.6017	86.57	0.1632	1.17885	1.44
83.9691	99.36	0.0816	1.15154	1.65
90.9624	77.72	0.0816	1.08033	1.29
94.7783	56.58	0.1224	1.04665	0.94
96.5044	18.19	0.4896	1.03246	0.30

2.4 Strain Calculations:

$d = 1.03246\ A^{\circ}$ @ $2\theta = 96.5044^{\circ}$

$d_o = 1.03468\ A^{\circ}$ @ $2\theta = 96.2292^{\circ}$

Strain = $(d - d_o) / d_0$

$€ = (1.03246 - 1.03468) / 1.03468$

$€ = -2.145 \times 10^{-3}$

III. CONCLUSION

Atomic spacing is more in unstressed condition as compared to atomic spacing in stressed condition at 100% relative intensity. Strain within the body can be very well calculated using simple empirical equation and negative sign indicates that the bond is inter atomic .Strain calculations may prove to be use full in predicting modulii and various other parameters of concrete.

Acknowledgements

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