PRELIMINARY INVESTIGATION REPORT ON BUILDING COLLAPSE AT BUWELIKADA, KANDY

REPORT No. NBRO/PMD/2020/CR-GG-54

PROJECT MANAGEMENT DIVISION
NATIONAL BUILDING RESEARCH ORGANISATION
(State Ministry of Internal Security, Home Affairs and Disaster Management)

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September 2020

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PRELIMINARY INVESTIGATION REPORT ON BUILDING COLLAPSE AT BUWELIKADA, KANDY
REPORT No. NBRO/PMD/2020/GG-54

1. INTRODUCTION

1.1 This report was prepared further to the report submitted by National Building Research Organisation (NBRO) with No. NBRO/LRRMD/LI/KN/GWK/20/31/00893 dated on 2020.09.21 about the collapse of a four-story building at No. 10/C, Sangamitta Mawatha, Kandy on to two other buildings in the Buwelikada Grama Niladari area, Gangawata Korale Divisional Secretariat Division in Kandy District on 20th September 2020.

1.2 Accordingly, a site investigation was conducted by a NBRO Expert Team comprising of the following NBRO officers and experts on 20th to 24th September 2020 in order to ascertain the condition of the collapse,

<u>NBRO officers and experts participated:</u>

- Eng. (Dr.) H.P. Sooriyaarachchi - Consultant - Structural Engineering
- Eng. (Mrs.) S.S.K. Muturathna - Director / Building Materials Research and Testing Division
- Geol. H.M.L. Indrathilaka - Charted Geologist / Landslide Research & Risk Management Division
- Mr. B.G.S. Kumara - Geologist / District Officer, Kandy
- Eng. (Ms.) G.K.B.M. Gannoruwa - Material Engineer / Building Materials Research and Testing Division
- Eng. A.M.R.S. Amarathunga - Civil Engineer / Project Management Division
- Eng. G.I.T.R. Ramawickrama - Civil Engineer / Project Management Division
- Mr. Dhanushka Jayathilake - Scientist / Human Settlements Planning and Training Division

2. GENERAL OBSERVATIONS

2.1 Google image of the site

Figure 01 below show Google image of the location of the collapse building.

Figure 01. Google Image showing location of the premises

2.2 Survey Plan

Part of the Survey Plan extracted from Survey Plan No. 441[B] (ANNEX I) which was received from Municipal Council, Kandy showing the site as follows:

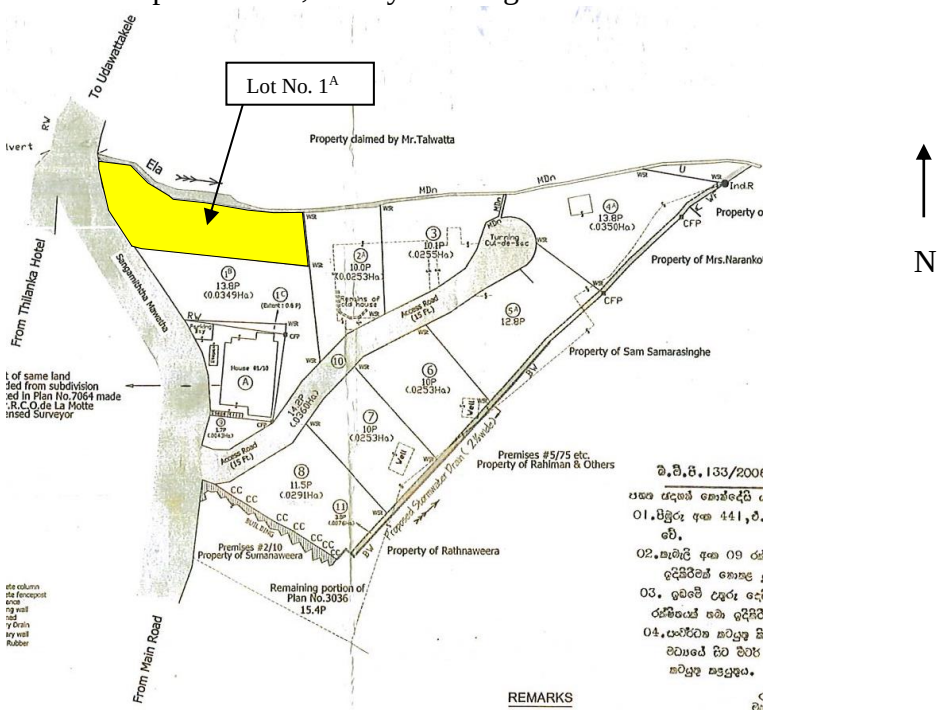

Figure 02. Part of the Survey Plan (Not to scale)

2.3 Photograph- before collapse

Figure 03 (a) shows the front view of the building before the collapse.

Figure 03 (a). Front view of building before the collapse (source: Google street view)

Figure No.03 (b) shows the side view of the building before the collapse.

Figure 03 (b). Side view of building before the collapse (source: Google street view)

2.4 Photograph- Situation at time of inspection

Following Figure No. 04 shows the situation of the premises at the time of inspection.

Figure 04. Status at the time of inspection

Above premises were inspected by the NBRO Expert Team and the observations at the time of inspection are given below:

2.5 Geotechnical Observations

I. There were no visible signs of slope failure, landslide and ground subsidence observed at the collapsed building site.

II. The investigated site is located on the right bank of a (RHS) minor valley.

III. Existing surface and subsurface drainage system have been blocked by the construction of the building and other structures in the vicinity and necessary arrangement for drainage facilities have not been provided and maintained during the construction.

IV. There is no movement of soil observed in any other parts of this land or the adjacent lands except for the soil movements due to uprooting of the foundation and retaining structures of the collapsed building and the movement of the building after the collapse.

V. The municipal storm water drainage between collapsed building and the building where the three victims of this tragic event lived (the annexed of the hotel building No.117/4, Sangamitta Mawatha, Kandy) is currently blocked by the fallen debris.

VI. Ground cracks and subsidence along the above cracks have been observed on the Sangamitta Mawatha subsequent to building collapse due to removal of the lateral earth pressure previously provided by the collapsed building and its supportive structures. At the same time some building structures also can be seen resting on the above unstable soil masses.

2.6 Structural Observations

I. According to the council approved drawing No. BA/573/2015 dated 2016.02.15 (Annex II), this was a four storied building (basement 1 + basement 2 + ground (road level) + upper ground) which consisted of reinforced concrete column & beam frame with approximately 4" thick reinforced concrete floor slab. However, during the investigation, it was observed that there were 3 Nos basements in the collapsed building. Existence of this 3rd basement has to be verified by inspection time of debris removal.

II. Single brick non load bearing type had been used to infill the reinforcement frame structure and for the partitioning work.

III. Building had been constructed on steep sloping ground. One end of this site where the building was located borders to a storm water drain maintained by the Kandy Municipal Council.

IV. Towards downstream the edges of this concrete lined drain are retained by random rubble masonry.

V. Close observations suggest that basement 1 columns and basement 2 columns towards far-left hand corner of the building, when you face the building from Sangamitta Mawatha have disintegrated (crushed) with no signs of their existence except for some distorted reinforcement. It is clearly observed that the slabs of the basement 1 and basement 2 have folded on top of each other and is currently resting on the ground at the left-hand corner of this collapsed building.

VI. The structure is not found to be a robust design, if at all it is designed and constructed adhering to a design guideline and recommendations. Structure did not wither integrity and continuity required and have collapsed after collapse of certain structural elements.

Robustness of the structure is an integral part of the design and design consideration of any structure and the lack of this had led to the progressive collapse of this structure. Based on these descriptors structure can be classified as a weak structure.

VII. It seems that two neighboring structures received massive blows from the falling debris of the collapsed structure. The neighboring structure at No. 117/4, Sangamitta Mawatha, where the three fatalities were recorded, and in the building at No. 10/A, Sangamitta Mawatha, the damage to the structure is still localized and has no danger of progressive failure or total disintegration as experienced by the collapsed structure.

VIII. There are clear evidences, especially in the column elements, signs of disintegration from the main floors during collapse characterized by the formation of pin joints between column and floor level connections.

IX. According to the council approved drawings received from Municipal Council, Kandy there are clear signs that approval for this building had been obtained at three separate occasions starting from 2007 and the last in 2016 (Refer Annex II). Original approval was only for a two storied building. (No. BA/245/2007 dated on 2007.05.04). It is highly questionable how a structure that was primarily designed for two storied building evolved into a four storied structure include extensions in lateral directions as well. This is very different to getting an approval for a four storied building initially and constructing the structure in different stages.

X. Observations made after the building collapsed revealed that there is wide variation of concrete strength in the building. While slab and beam recorded considerably high strength in excess of 35MPa in some instances, some other samples extracted from the columns recorded as low as 11Mpa (Annex III). It is therefore deemed necessary to investigating the strength of building elements in reference to their different stages of construction.

3. CONCLUDING REMARKS AND RECOMMENDATION

The main findings and the conclusion of the report are as follows.

3.1 Above observations eliminate Slope Failure, Landslide or Ground Subsidence as possible causes of the building failure.

3.2 There is a need of cleaning the Municipal drain which is currently blocked by the fallen debris from the collapsed building in order to maintain the unhindered flow of storm water. Until then, a proper surface drainage system (temporary) must be introduced to minimize the entering of surface runoff into the building collapse area.

3.3 Current observations have strongest inclination towards building failure triggered due to a structural failure of some of its elements. It is also found that the building structure was not robust enough to resist a progressive collapsing of the building.

3.4 Disintegration of the collapsed structure is not complete yet. There are still lot of debris hanging all over the place in unstable condition. Falling of debris is possible causing further damage to the adjacent buildings. Specially to the house at No. 117/4, Sangamitta Mawatha, Kandy, which now supports most of the debris load of the fallen structure. Further disintegration of the collapse building can cause extended damage to this building. Therefore, it is strongly recommended to start the removal of debris from the site.

3.5 During the removal of debris of the collapsed building, damage to the existing natural slopes must be minimized.

3.6 Part of the existing retaining wall/ blind wall adjacent to the Sangamitta road should not be removed until the proper mitigation measures are introduced.

3.7 Existing building parts resting on the unstable soil mass which are located on the soft shoulder and entrance of the collapsed building should be removed immediately to reduce the load on unstable soil mass.

3.8 Removal of the lateral load provided by the collapsed building to the existing slope will lead to progressive failures / continuation of future failures on the slope bordering Sangamitta Mawatha.

3.9 After the removal and disposal of collapsed building structure and debris, there will be no danger to land and it will be then safe to re-occupy the temporarily evacuated neighborhood.

3.10 Further investigation into the cause of collapse can be greatly assisted by careful removal of roof structure, floor slabs one by one after lodging structural failures sustained at different levels. This need to be specially done at the point of removal of the first floor to clearly conclude whether the final collapse of this fragile structure was triggered by foundation failure or failure in the super structure elements and how the initial failures of structural elements has led to the progressive collapse of the building.

Prepared by:

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.....

Eng. (Ms.) Nirmanthi Idirimanna
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.....

Mr. Samantha Bogahapitiya
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.....

Mr. Dhanushka Jayathilake
Scientist / Human Settlements Planning and Training Division

Recommended by:

.....

Eng. (Dr.) H.P. Sooriyaarachchi
Consultant - Structural Engineering

Approved by:

.....

Eng. (Mrs.) J. K. Jayawardena
Director/ Project Management Division

Eng.J.K. Jayawardena
Director
Project Management Division
National Building Research Organisation

Date: 30.09.2020

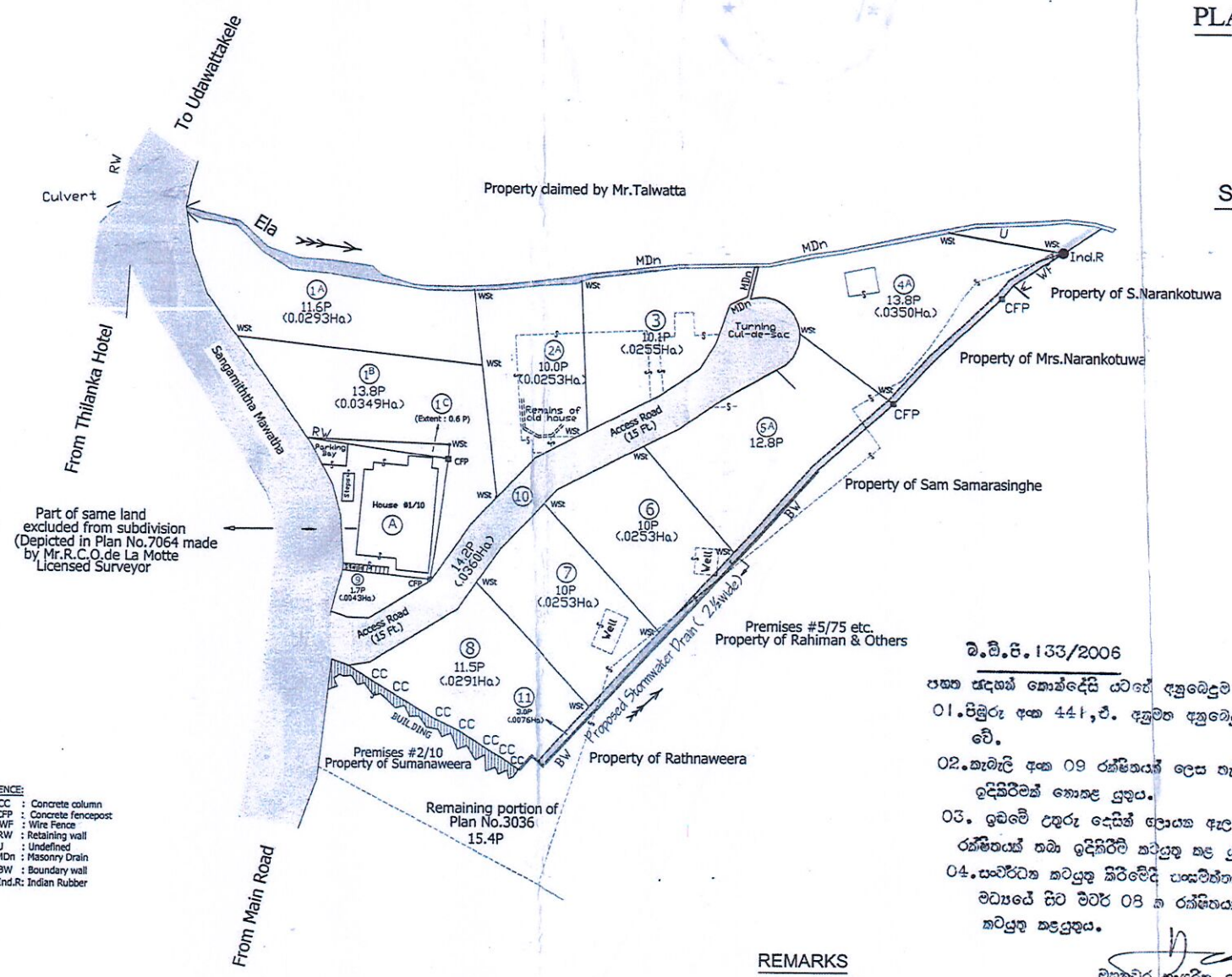
Annex I

K.W.M.VICTOR MAPITIGAMA [FSI,CSSI]
Chartered Licensed Surveyor,
Valuer & Court Commissioner
(Regd. No.050118)
24,Uplands, Kandy
Tel: 081-2232099, 0777-843569
Fax :081-2232099
e-mail :

PLAN No. 441B

N

Scale 1:500



REFERENCE:
- CC : Concrete column
- CFP : Concrete fencepost
- WF : Wire Fence
- RW : Retaining wall
- U : Undefined
- MDn : Masonry Drain
- BW : Boundary wall
- Ind.R: Indian Rubber

 බ.බී.පී. 133/2006

පහත සඳහන් කොන්දේසි යටතේ අනුබෙදුම අනුමත කරමි.

01. පිඹුරු අංක 441,ඒ. අනුමත අනුබෙදුම පිඹුර අවලංගු වේ.

02. කැබැලි අංක 09 රක්ෂිතයක් ලෙස තැබියයුතු අතර කිසිදු ඉදිකිරීමක් නොකළ යුතුය.

03. ඉඩමේ උතුරු දෙසින් ලොයක ඇල සඳහා අඩි 5 ක රක්ෂිතයක් තබා ඉදිකිරීම් කටයුතු කළ යුතුය.

04. සංවර්ධන කටයුතු කිරීමේදී සංසම්පන්න පාවිච්චි මාර්ග මධ්‍යයේ සිට මීටර් 08 ක රක්ෂිතයක් තබා ඉදිකිරීම් කටයුතු කළයුතුය.

මහනුවර-නාගරික කොමසාරිස්
2006.07.-21

REMARKS

1. Boundaries of my survey showing the current as-built position are shown in firm black lines
2. Boundaries of Mr.B.P.Rupasinghe,Licensed Surveyor's Plan No. 3036, where descrepant from my survey are indicated in red broken lines
3. Buildings and structures shown in Mr.Rupasinghe's aforesaid Plan which are not in existence now, are shown in dark grey lines.
4. Average MSL value of each Lot is shown in blue.

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නාගරික කොමසාරිස්
මහනුවර මහ නගර සභාව.

NOTES:
1. B.O.P. approval : BOP 181/2005 dated 15th September 2005 of the Municipal Commissioner,Kandy
2. This sub-division Plan supercedes my Plan No. 441A dated 21.08.2005 (This Plan is a modification of my Plan No.441A).

PLAN
showing
Sub-division
of
a divided portion of land
called
"THE DALE"
Bearing Assmt. No.10,Sangamitta Mawatha
(Formerly called Lady Mc Carthy's Road)
depicted as Lot A(Part of) of Plan No.581 dated 21-10-1953
made by Mr.R.C.O.De La Motte, Licensed Surveyor
subsequently surveyed as Lot 1 (Part of) and depicted in Plan No.3036
made by
Bernard P.Rupasinghe,Licensed Surveyor
Situated at
Buwelikada
within
the Municipal Council limits of Kandy
Kandy District
CENTRAL PROVINCE
(Boundaries as described above)

LOT NO.	EXTENT R.P.(Ha)	REMARKS	NORTH	EAST	SOUTH	WEST
1A	11.6P (0.0293Ha)	Parts of Lots 1 & 2 of my Plan No.441A dated 21.08.2005	Ela and property claimed by Mr.Talwatta	Lot 2A of same Plan	Lot 1B of same Plan	Sangamitta Mawatha
1B	13.8P (0.0349Ha)	Parts of Lots 1 & 2 of my Plan No.441A dated 21.08.2005	Lot 1A of same Plan	Lot 2A of same Plan	Lot 1C of same Plan	Sangamitta Mawatha
1C	0.6P (0.0015Ha)	Part of Lot 1 of my Plan No.441A dated 21.08.2005	Lot 1B of same Plan	Lot 2A of same Plan	Premises No.1/10 of Sangamitta Mawatha	Sangamitta Mawatha
2A	10.0P (0.0253Ha)	Part of Lot 2 of my Plan No.441A dated 21.08.2005	Ela and property claimed by Mr.Talwatta	Lot 3 of same Plan	Lot 10 of same Plan (15 Ft. Accessway)	Lots 1A,1B &1C of same Plan and Premises No.1/10 of Sangamitta Mawatha
3	10.1P (0.0255Ha)	Lot 3 of my Plan No.441A	Ela and property claimed by Mr.Talwatta	Lot 4A of same Plan	Lot 1B of same Plan	Sangamitta Mawatha
4A	13.8P (0.0349Ha)	Part of Lot 4 of my Plan No.441A dated 21.08.2005	Ela and property claimed by Mr.Talwatta	Property of Ms.Narankotuwa	Lot 5A of same Plan and Property of Ms.Narankotuwa	Lot 10 and Lot 5A of same Plan
5A	12.8P (0.0324Ha)	Lot 5 and Part of Lot 4 of my PlanNo.441A	Lot 10 (15 Ft. Accessway) and Lot 4A of same Plan	Properties of Ms.Narankotuwa and Sam Samarasinghe	Lot 6 of same Plan and property of Sam Samarasinghe	Lot 10 (15 Ft. Accessway) Lot 6 of same Plan
6	10.0P (0.x0253Ha)	Lot 6 of my PlanNo.441A	Lot 10 of same Plan (15 Ft. Accessway)	Lot 5A and 11 of same Plan	Lot 7 of same Plan and Premises # 5/75	Lot 10 (15 Ft. Accessway) Lot 7 of same Plan
7	10.0P (0.0253Ha)	Lot 7 of my PlanNo.441A	Lot 10 (15 Ft. Accessway) and Lot 6 of same Plan	Lot 11 of same Plan	Lots 11 & 8 of same Plan	Lots 8 & 10 of same Plan (15 Ft. Accessway)
8	11.5P (0.0291Ha)	Lot 8 of my Plan No.441A	Lot 10 (15 Ft. Accessway) and Lot 7 of same Plan	Lot 11 of same Plan and Premises # 2/10 of Mr.Sumanaweera	Premises # 2/10 of Sumanaweera and remaining portion of Lot 1 of Plan # 3036	Premises # 2/10 of Sumanaweera
9	1.7P (0.0043Ha)	Lot 9 of my Plan No.441A	Premises #1/10 of Sangamitta Mawatha	Lot 10 of my Plan No.441A (15 Ft. Accessway)	Lot 10 of my Plan No.441A (15 Ft. Accessway)	Sangamitta Mawatha
10	14 .2P (0.0359Ha)	Lot 10 of my Plan No.441A (15 Ft. Accessway)	15 Ft Accessway			
11	3.0P (0.0076Ha)	Lot 11 of my Plan No.441A (Reservation for Drain)	Reservation for Storm water Drain			

Plan No.441A referred to, is the first subdivision Plan dated 21.08.2005, which is now supercede by this Plan.

True copy
at. Perera
2007/03/04.

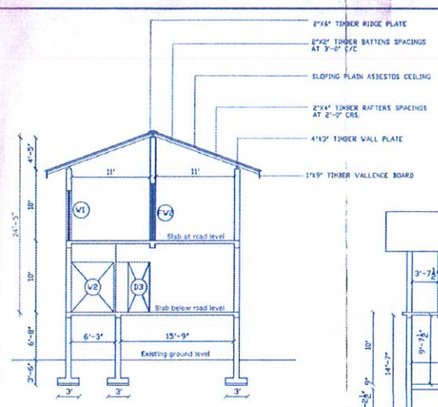
K.W.M. VICTOR MAPITIGAMA (CSSI, FSI)
Licensed Chartered Surveyor, Leveller, Valuer & Court Commissioner (Regd. No. 050117)
Tel : 081-2232099, 0777-843569

17th June 2006

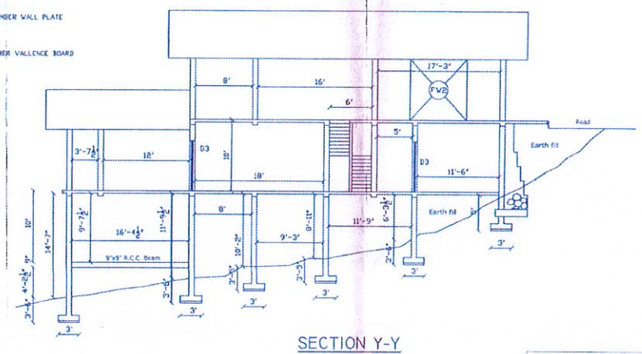
Annex II

FRONT ELEVATION

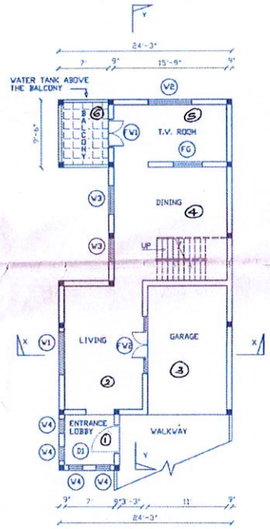
LEFT SIDE ELEVATION



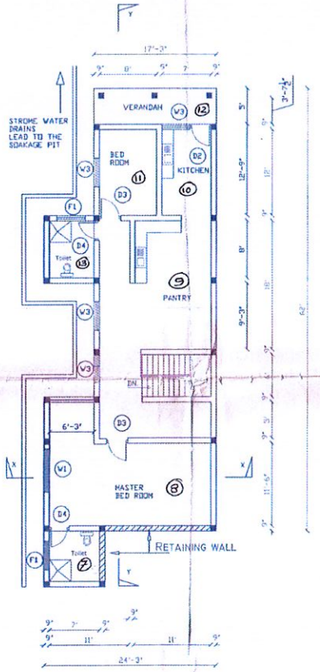
SECTION X-X



SECTION Y-Y



PLAN AT ROAD LEVEL

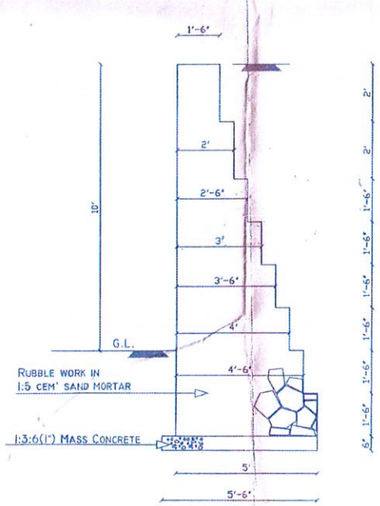


PLAN BELOW ROAD LEVEL

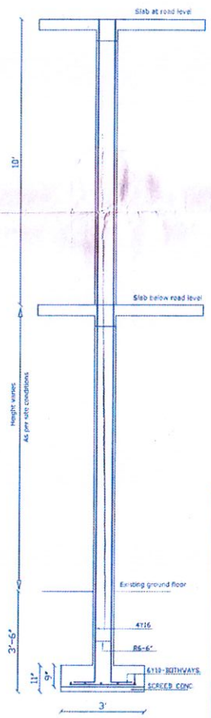
සටහන්වලට:—

1. කාමරයේ 2 හා 8 කාමර සඳහා තාපාලෝක ලබා ගැනීමට තමා තුනින් තරම් අමුම අර 7½% තබා ඉදිකිරීම කළ යුතුය.

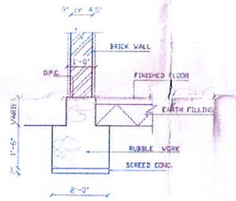
2. සොකුණු කෝණිකයන් රඳවනයන් තැබිය යුතුය.



10'-0" HIGH RETAINING WALL

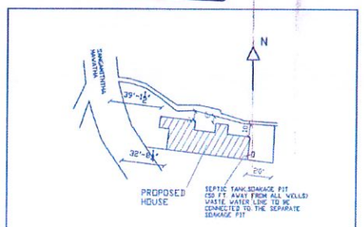


COLUMN DETAIL



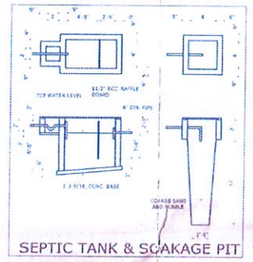
FOUNDATION DETAIL

B.G. Gunasiri
B.Sc. Eng.(Hons.), C.Eng., MIE(SL), M(ASI)
(Chartered Civil Engineer)
No 102, "Summer Field"
Moragahapitiya Estate
Balagolla, Kandy.



SITE PLAN

SCALE: 1:500



SEPTIC TANK & SOAKAGE PIT

TYPE	SIZE	DESCRIPTION	SILL HFROM FFL	Nos.
D1	4'-0"x8'-6"	DECORATIVE SOLID TIMBER DOOR WITH LOUVERS ABOVE	+0	01
D2	3'-0"x8'-6"	TIMBER DOOR WITH LOUVERS ABOVE	+0	01
D3	3'-0"x7'-0"	TIMBER DOOR	+0	02
D4	2'-9"x7'-0"	TIMBER DOOR	+0	02
W1	6'-0"x7'-0"	GLAZED TIMBER WINDOW WITH LOUVERS ABOVE	+1'-0"	02
W2	6'-0"x5'-6"	GLAZED TIMBER WINDOW WITH LOUVERS ABOVE	+3'-0"	02
W3	4'-0"x5'-6"	GLAZED TIMBER WINDOW WITH LOUVERS ABOVE	+3'-0"	06
W4	2'-0"x5'-6"	GLAZED TIMBER WINDOW WITH LOUVERS ABOVE	+3'-0"	04
FG	4'-0"x4'-0"	GLAZED TIMBER FIXED GLASS	+3'-0"	01
FW1	4'-0"x8'-6"	GLAZED TIMBER FRENCH WINDOW WITH LOUVERS ABOVE	+0	01
FW2	8'-0"x8'-6"	GLAZED TIMBER FRENCH WINDOW WITH LOUVERS ABOVE	+0	01
F1	4'-0"x3'-6"	GLAZED TIMBER FANLIGHT WITH LOUVERS ABOVE	+5'-0"	02

FLOOR AREAS:
GROUND FLOOR - 1338.12 SQ.FT.
UPPER FLOOR - 1026.9350 SQ.FT.
TOTAL AREA - 2360.05 SQ.FT.

PRROJECT

PROPOSED RESIDENCE
FOR MRS. L.G.S. PATHIRANA OF 10/3
SANGAMITTA MAWATHA, KANDY.

COUNCIL DRAWING

APPLICANT'S SIGNATURE

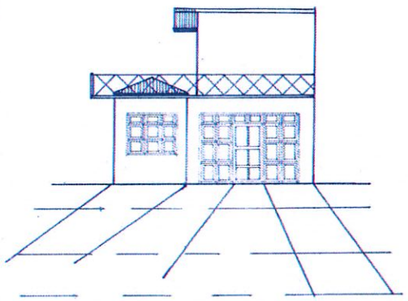
DESIGNED:

SCALE 16 FT. = 1 INCH
2 FT. = 1 INCH

DATE: 08/02/2007

CAD BY:

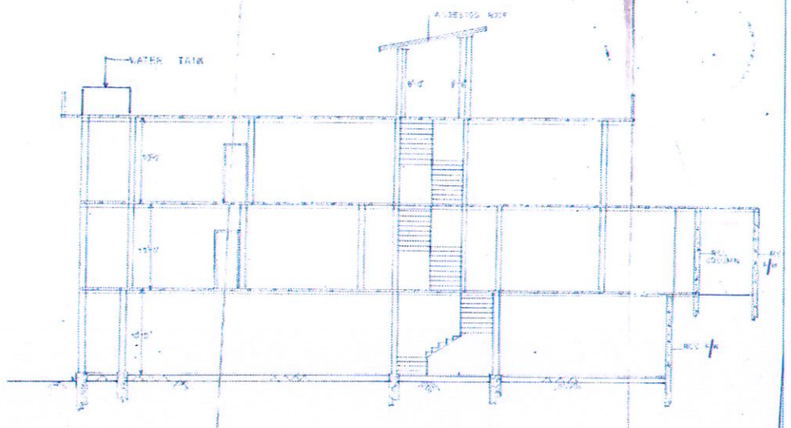
DRG NO VEE/AD/200702/04



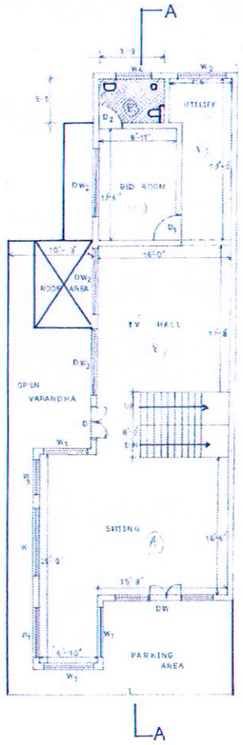
FRONT ELEVATION

මේකෙන් පෙන්වලා තියෙන්නේ සඳහන් සංගෝධන ඇතුළුව බලපත්‍රය නිකුත් කරලා තියෙන්නේ.
කෙලින්ම කොන්ක්‍රීට් වැහිලාමයි තියෙන්නේ.

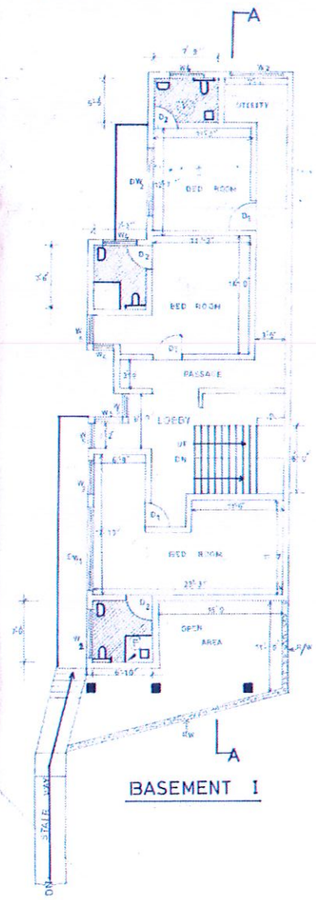
SIDE ELEVATION



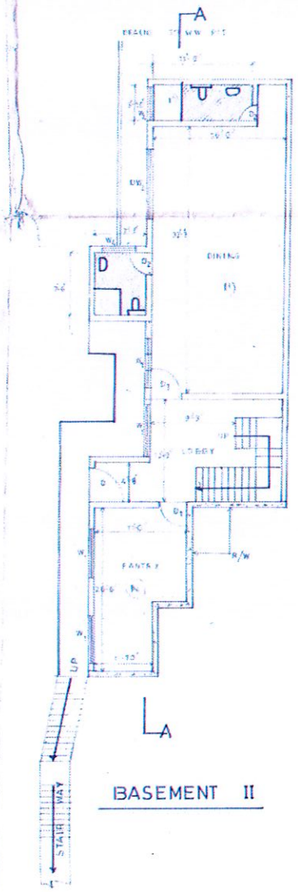
SECTION A - A



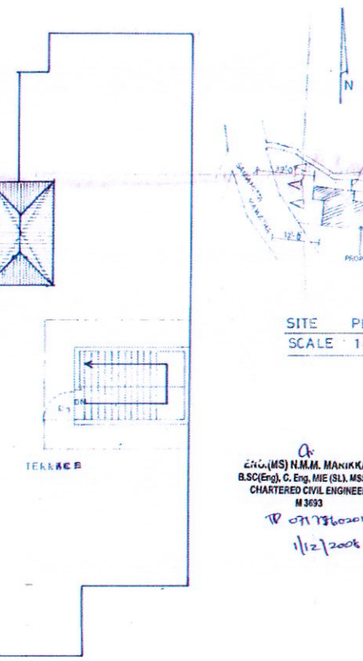
ROAD LEVEL



BASEMENT I



BASEMENT II



ROOF SLAB

SITE PLAN
SCALE 1:500

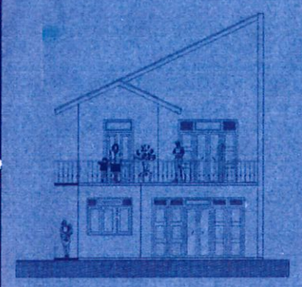
SCHEDULE OF OPENINGS

TYPE	DIM	DESCRIPTION	NOS
D	2'-5" x 6'-8"	FLUSH PANELLED DOOR	02
D1	[illegible]	PLYWOOD DOOR	03
D2	[illegible]	—	06
LW	[illegible]	GLASS DOOR WINDOW	05
DW1	[illegible]	—	08
DW2	[illegible]	—	06
W	[illegible]	ALUM. WINDOW	01
W1	[illegible]	—	08
W2	[illegible]	—	03
W3	[illegible]	—	02
W4	[illegible]	—	04
W5	[illegible]	—	04
W6	[illegible]	—	04

SCALE - 6 FEET TO AN INCH

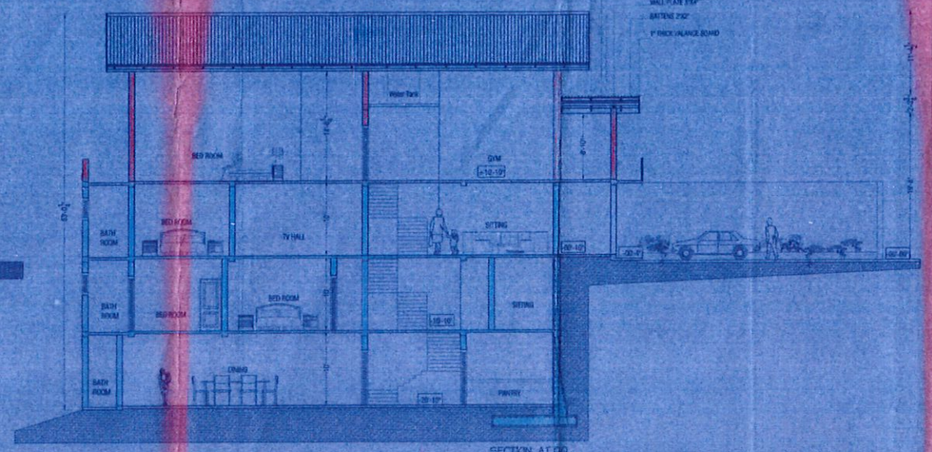
ENG.(MS) N.M.M. MANIKKAR
B.SC(Eng), C. Eng. MIE (SL), MSSt.E
CHARTERED CIVIL ENGINEER
M 3693
☎ 0717860201
1/12/2006

APPROVED PLAN NO: BA 245 2007
AMMENDED PLAN
AT NO: 10/3,
SANGAMITTA MAWATHA,
KANDY.
FOR MRS L. G. S. PATHIRANA
Applicant.



ROAD SIDE ELEVATION

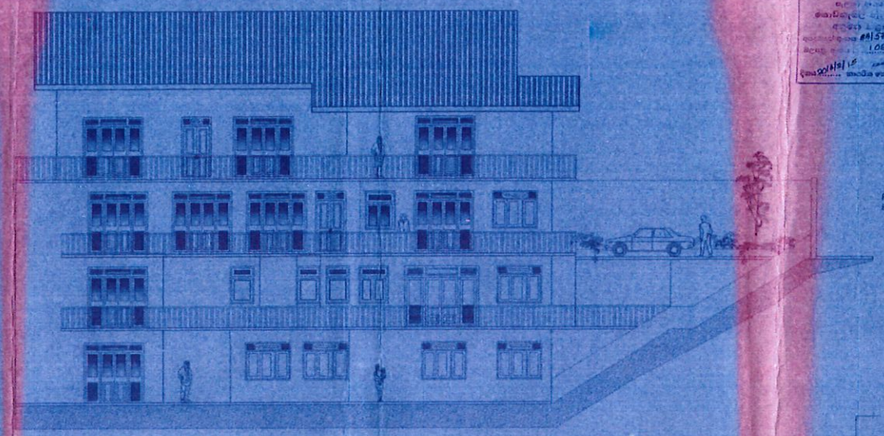
SCALE: 1/8" - 1'-0"



SECTION AT:BB

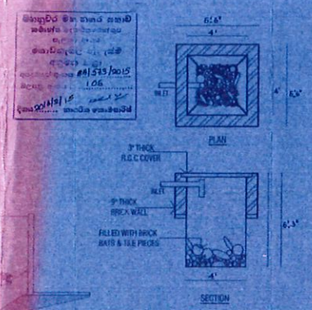
SECTION AT:AA

SCALE: 1/8" - 1'-0"



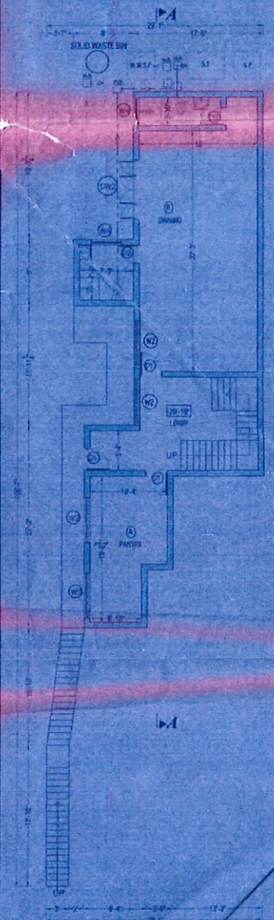
SIDE ELEVATION

SCALE: 1/8" - 1'-0"



WASTE WATER SOAKAGE PIT

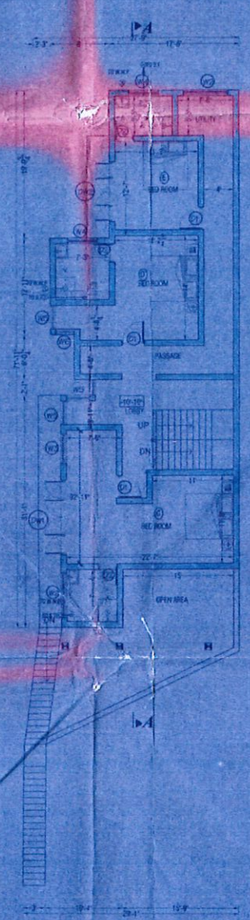
SCALE: 4 FEET TO AN INCH



BASEMENT 02 PLAN

SCALE: 1/8" - 1'-0"

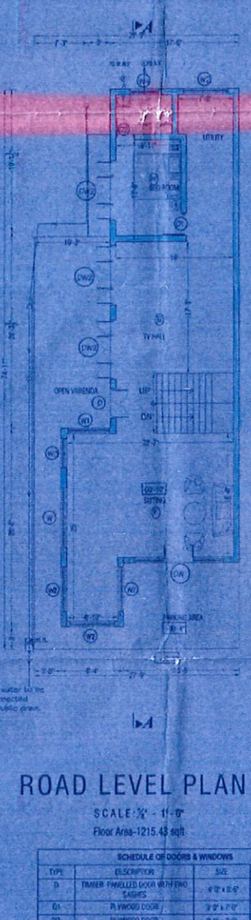
Floor Area-1232.63 sqft



BASEMENT 01 PLAN

SCALE: 1/8" - 1'-0"

Floor Area-1351.59 sqft

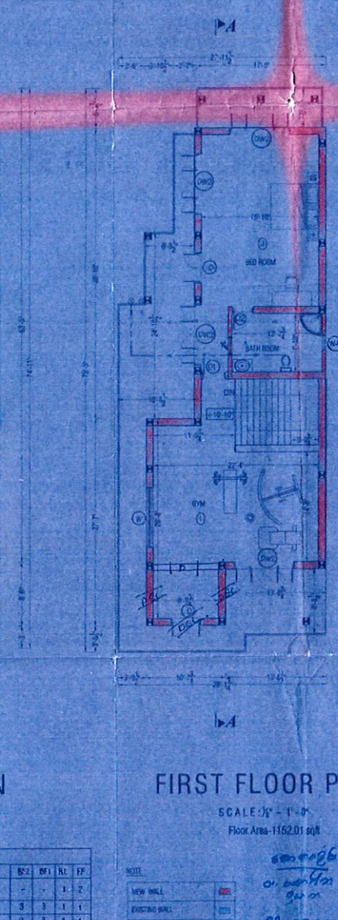


ROAD LEVEL PLAN

SCALE: 1/8" - 1'-0"

Floor Area-1215.43 sqft

SCHEDULE OF DOORS & WINDOWS						
TYPE	DESCRIPTION	SIZE	B/Z	B/L	R/L	F/F
D	TIMBER PANELLED DOOR WITH FINO FASHES	4'0"x8'0"	-	-	3	2
D1	PLYWOOD DOOR	3'0"x7'0"	3	3	1	1
D2	PLYWOOD DOOR	2'6"x7'0"	2	3	1	1
W4	GLAZED FANLIGHT	4'0"x5'0"	2	3	1	1
DW2	FRENCH WINDOW	4'0"x8'0"	1	2	3	4
W	GLAZED WINDOW	8'0"x5'0"	-	-	1	1
W2	GLAZED WINDOW	6'0"x5'0"	4	2	6	-
W3	GLAZED WINDOW	6'0"x3'0"	-	4	1	-



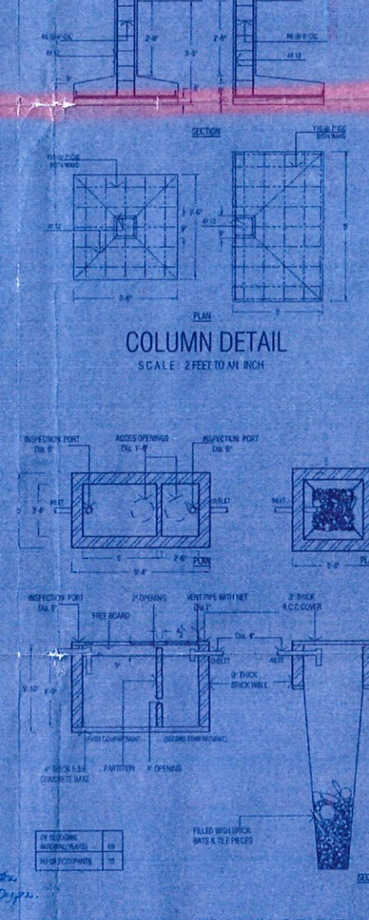
FIRST FLOOR PLAN

SCALE: 1/8" - 1'-0"

Floor Area-1152.01 sqft

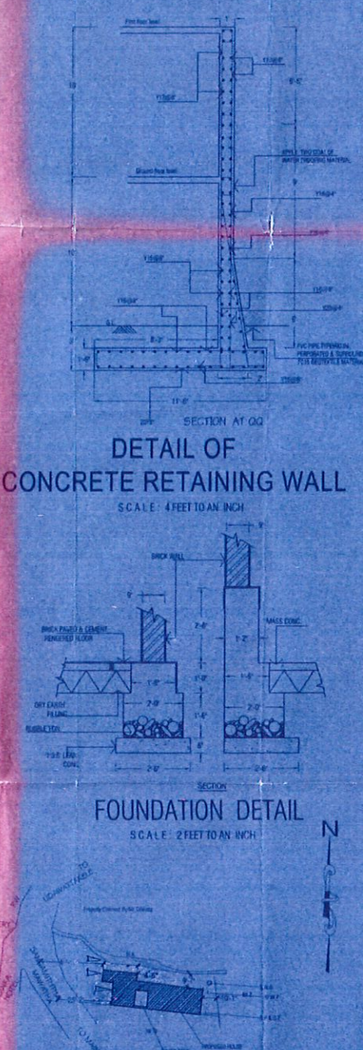
ROOF PLAN

SCALE: 1/8" - 1'-0"



COLUMN DETAIL

SCALE: 2 FEET TO AN INCH



DETAIL OF CONCRETE RETAINING WALL

SCALE: 4 FEET TO AN INCH

SEPTIC TANK & SOAKAGE PIT

SCALE: 4 FEET TO AN INCH

FOUNDATION DETAIL

SCALE: 2 FEET TO AN INCH

SITE PLAN

SCALE: 1:500

AMENDMENT PLAN NO BA/245/2007, OF HOUSE FOR MR. L.G.S. PATHIRANA,10C,LEWKE GARDEN,SANGAMITHTHA MAWATHA,KANDY.

DESIGNED BY: CHARTERED ARCHITECT P. JAGATH NISHANTHA B.Sc.(B.E.) (M.Sc.)(Arch. Mgt.) (Lond.) (A.M.I.B.E.) (A.M.I.A.) (Sri Lanka) 10/10 LEWKE GARDEN ROAD, KANDY

Reg. No. CA 00820

ARCHT. P. J. NISHANTHA (AMCBL)

DRAWN BY: D.S.K.I.ATHUKORALA

APPLICANT'S SIGNATURE

CHECKED BY: This is to certify that I have designed and checked this building / retaining structure considering the stability and the ground conditions to sve against all failures including bearing, sliding and overturning.

THE INSTITUTION ORGANIZERS BY: Eng. W.A. WIJEWARDHANA (PVT) LTD. CHARTERED ENGINEERS

SCALE: 1/8" = 1'-0"

DATE: 14/09/2010

DWG NO: 485

ANNEXURE

TESTING OF CONCRETE SAMPLES COLLECTED FROM COLLAPSED BUILDING AT SANGAMITHTHA MAWATHA, KANDY

1.0 SAMPLING LOCATION: Collapsed building at Sangamiththa Mawatha, Kandy

2.0 DATE OF SAMPLING: 24th September 2020

4.0 SAMPLE DESCRIPTION:

Table 1: Description of collected samples

Sample No.	Type of Material	Identification Mark
01	Concrete	1
02	Concrete	2
03	Concrete	3
04	Concrete	4 S - 1
05	Concrete	4 S - 2

Sampling locations are marked in relevant images in this annexure.

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BUILDING MATERIALS RESEARCH & TESTING DIVISION
NO. 99/1, JAWATTA ROAD,
COLOMBO 05.

4.1 Sampling Details

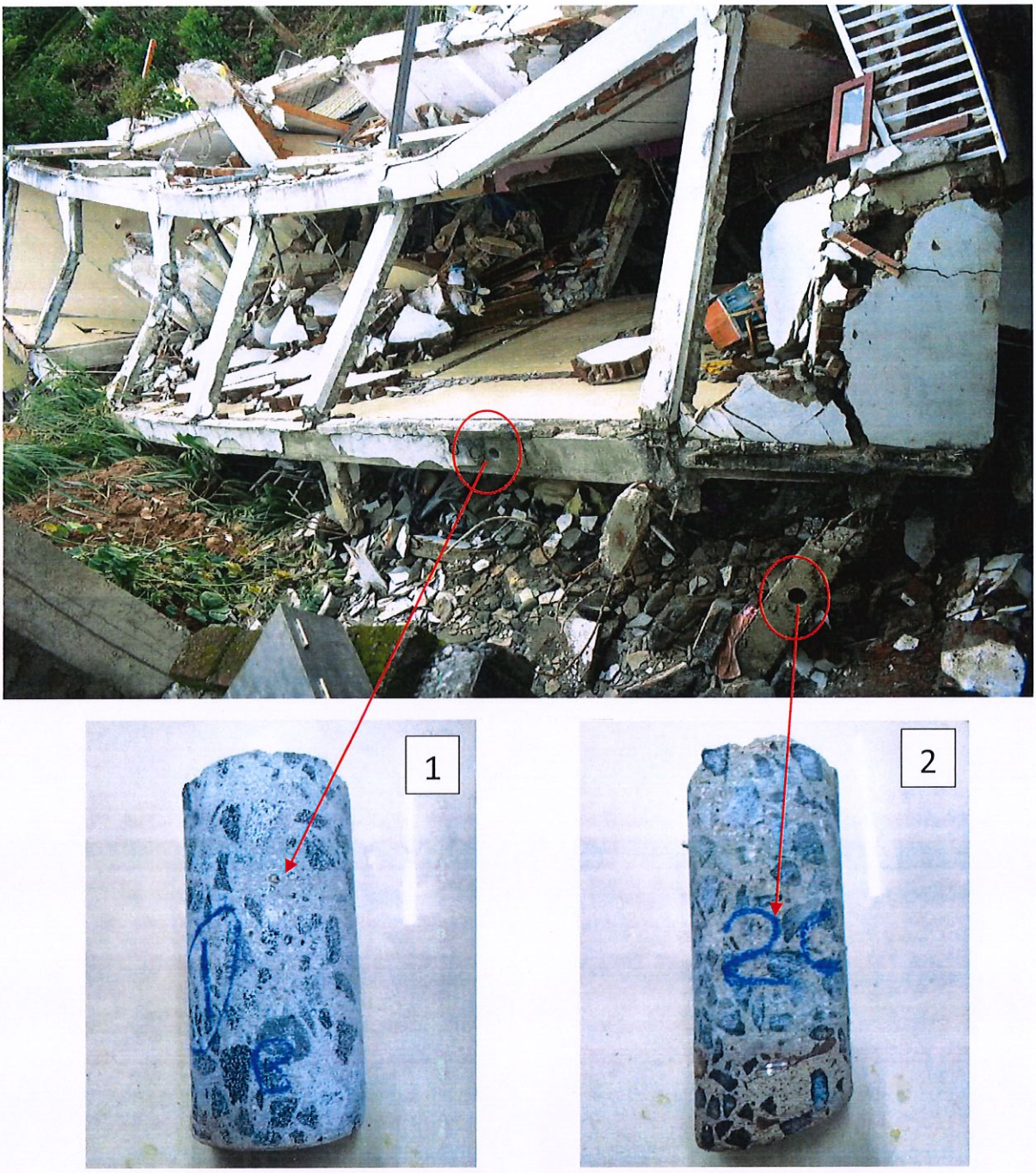

Figure 1: Concrete core samples taken from collapsed beam and column

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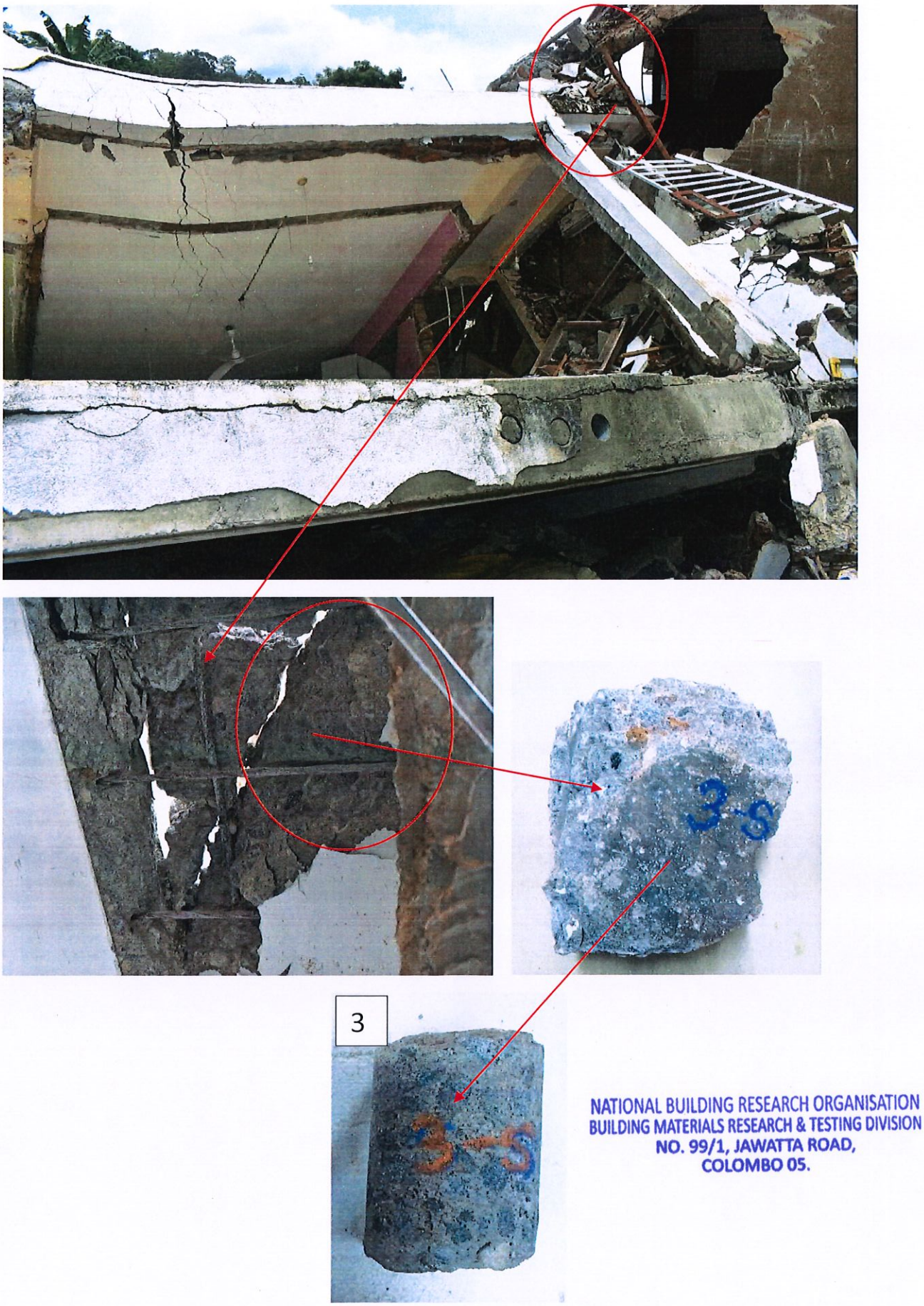

Figure 2: Concrete sample collected from collapsed slab located at partially damaged room side

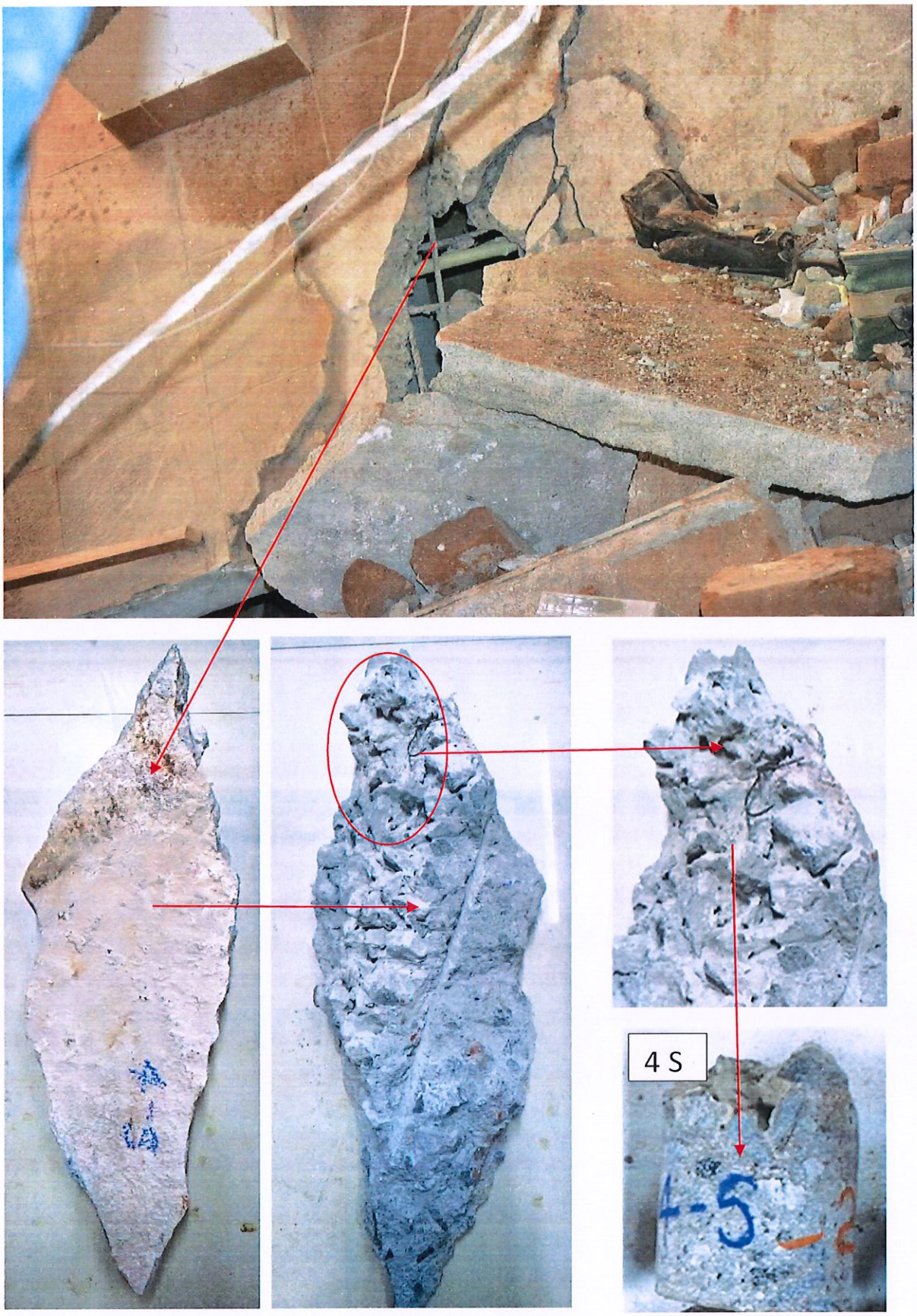

Figure 3: Concrete sample collected from collapsed slab located at damaged home side

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4.2 Compressive Strength Test Results of Concrete

Table 2: Test results of concrete samples

Serial No.	01	02	03	04	05
ID Mark	1	2	3	4S - 1	4S - 2
Diameter in mm (Av.)	98.5	98.5	74.3	74.1	74.2
Length as received (mm) (Avg.)	183	205	79	75	73
Length before testing in mm (Av.)	106	108	89	70	73
Weight of sample after cutting (g)	1987	1939	965	720	757
Density in kg/m^3 (based on measured dimension)	2461	2358	2500	2386	2399
Date of testing	28-Sep-20	28-Sep-20	28-Sep-20	28-Sep-20	28-Sep-20
Load in kN	246.3	84.5	86.6	186.2	163.8
Area of cross section in mm^2	7615.46	7615.46	4337.53	4311.30	4322.95
Measured compressive strength N/mm^2	**32.34**	**11.10**	**19.97**	**43.19**	**37.89**

Compressive strength test was performed as per method described in BSEN 12504-1: 2009; Testing concrete in structures, Part 1: Cored specimens – Taking, examining and testing in compression.

Testing Officer: _____
D.P. Gallage
MA- Technical

Checked by: _____
G.K.B.M. Gannoruwa
Materials Engineer

Certified by: _____
Eng.(Mrs.) S.S.K. Muthurathne
Director
Building Materials Research
& Testing Division

NATIONAL BUILDING RESEARCH ORGANISATION
BUILDING MATERIALS RESEARCH & TESTING DIVISION
NO. 99/1, JAWATTA ROAD,
COLOMBO 05.

4.3 Failure Pattern of Test Specimens

Before Failure **After Failure**

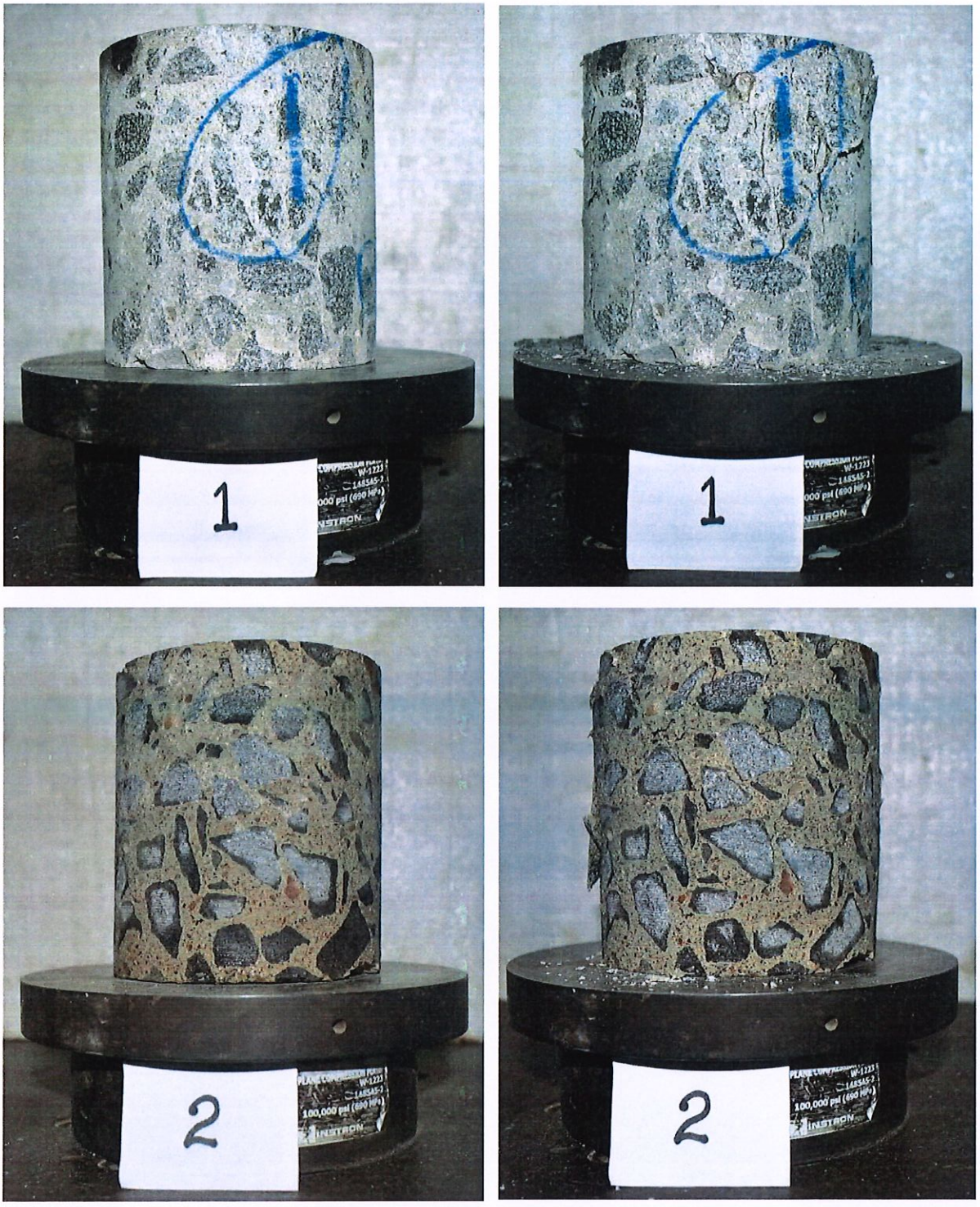

Figure 4: Test sample No. 1 & 2

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Before Failure **After Failure**

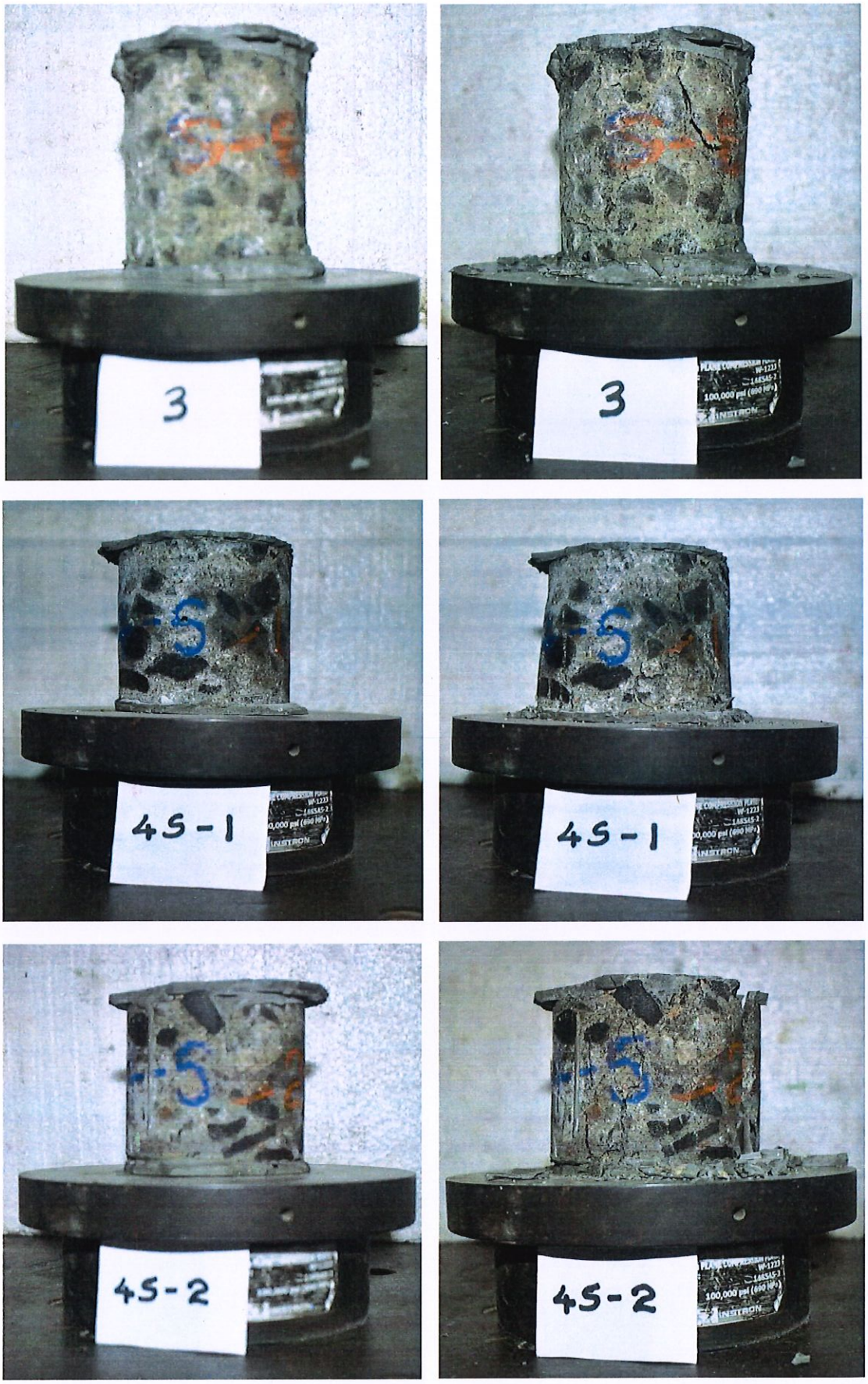

Figure 5: Test sample No.3, 4S-1 & 4S-2

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