Jacobs

Structural Appraisal of Bradford Interchange Bus Station

B2382824-JAC-S-R-XXX-002

27 February 2024

West Yorkshire Combined Authority

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
A	27/02/2024	Issued for review	DA	AD	AD	SM

West Yorkshire Combined Authority

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Author:	
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Contents

Appendices

1.0 Introduction

West Yorkshire Combined Authority (WYCA) has engaged Jacobs to undertake structural surveys of Bradford Interchange Bus Station, Bradford BD1 1TU.

The structure was built in the 1970s with a canopy over the underground car park. The canopy was later removed, and the bus station concourse building was built supported off the car park columns. The concourse building measures approximately 118 x 24 m.

The car park superstructure comprises a reinforced concrete beam and slab construction. The superstructure supports the interchange, trafficked predominantly by buses, running on concrete and asphalt surfacing with paving bricks/slabs around the perimeter of the concourse building. The concourse building roof is constructed of steel trusses spanning over columns. Adjacent to the structure are a multi-storey car park to the north, with commercial buildings to the west and south, and the Interchange rail link to the east, as depicted in the location plan below.

Jacobs was appointed following the identification of a piece of concrete, becoming dislodged from the superstructure slab soffit and previously identified leakage to the internal stairway, within the concourse building.

[redacted]

An initial report (Stage 1) was issued on 26th January 2024 following a survey carried out on 12th January 2024.

This report will focus on the additional investigation stated in the initial report (Stage 1) and will incorporate some of Stage 1 findings.

Location plan - Bradford Interchange Bus Station with underground car park

2.0 Description of the Survey

2.1 General Details

Jacobs carried out non-intrusive visual inspections of the bus station building and car park structures on 24-26th January and 9th February 2024.

There was some rain on 25th January and 9th February, and the temperature range was approximately 3-12°C for the 4 days. The inspection was undertaken during daylight hours.

2.2 Inspection Procedure

The condition of the internal and external areas of bus station building were inspected at close range from ground level.

The condition of the car park slab soffit, main beams and secondary beams of the structure were inspected at close range using a mobile elevated working platform.

A tape measure and crack gauge were used to identify the extent and location of any recorded defects.

A digital camera was used to record defects and general elevation photos.

Light hammer tapping was used around areas of defective concrete to remove any loose material and to identify areas of further deterioration.

A record of photographs taken during the inspection can be found in Appendix A.

The defects recorded during the inspection are shown on drawings included in Appendix B.

2.3 Limitations of the Inspection

The inspection was limited to areas of the structure to which access could be provided by the West Yorkshire Combined Authority. Access within the car park covered the majority of this area and was only inhibited by the presence of services such as drainage. Openings were cut through netting across the underside of the structure. [redacted]

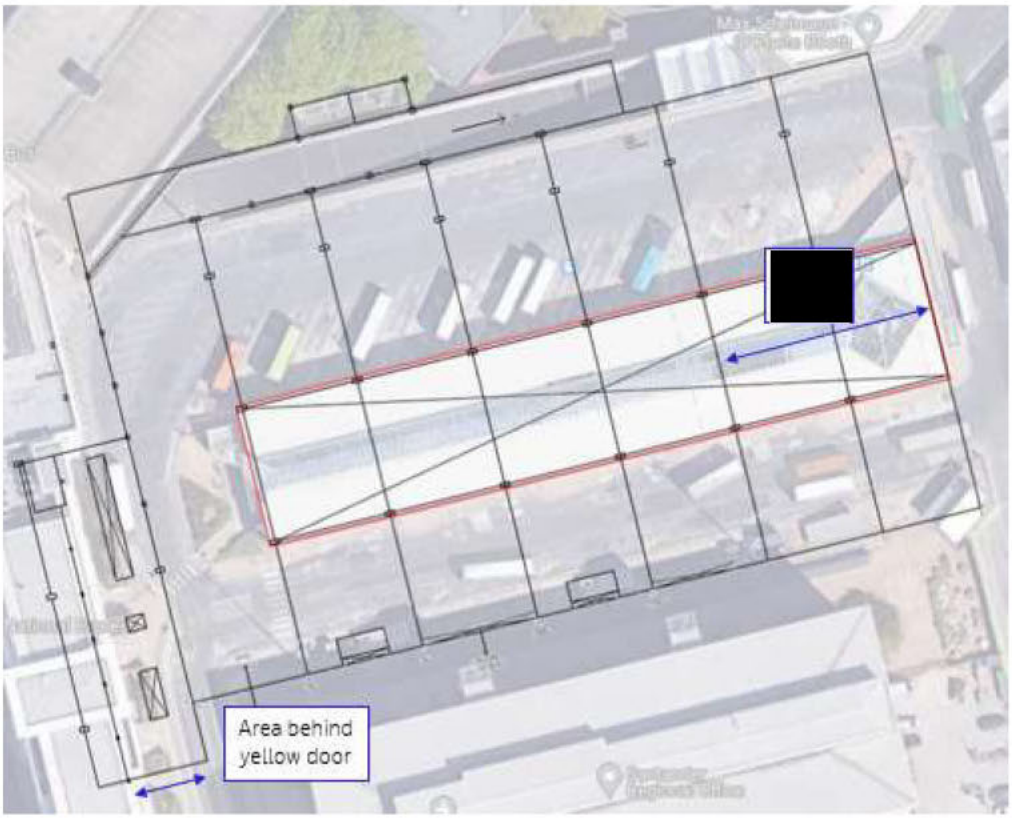
The top of the car park slab within the concourse building footprint was inaccessible at the time of inspection.

2.4 Structure Details

The following details were measured/estimated as part of the inspection or established based on available record information:

Slab depth (assumed)	150-200 mm
Main beam depth (from slab soffit)	2,500 mm (approximate)
Secondary beam depth (from slab soffit)	875 mm
Columns (typical)	1,500 x 750 x 5,000 mm
Column spacing	22,500 x 19,500 mm (approximate)
Height from ground slab to soffit of slab	7,527 mm (approximate)

2.5 Structure Layout



3.0 Survey Findings

3.1 Superstructure / Car Park Slab

Loose/defective concrete was apparent in 2No. locations; to the slab soffit beneath the west entrance to the concourse building and at the slab opening to the south-west stairwell.

Areas of white patches/efflorescence have been identified and can be found in the photos in Appendix A. They were also found around the slab close to the main beams.

The car park slab has been cut to allow for some building columns, with water leaks in those areas.

[redacted]

3No. fire exit stairs were holding water, with the passage of water identified as coming from the lightweight steel entrance structure above and defective drainage to the bottom of the roof structure (photos 98-101,136 and 137).

There were areas on top of the car park slab with some water ponding including barriers and signposts with concrete bases.

Water ingress through the stair wall was from the soffit of the slab (photos 102-103).

3.2 Bus Station / Concourse Building

The water observed within the concourse building was identified as coming from the roof and through the doors.

From drawings, the top of tiled floor level is 107.940 m AOD and the average level of top of car park slab is 107.550 m AOD, giving a depth of floor construction of the building at approximately 390 mm.

3.3 Lower Concourse

[redacted]

Water ingress was from the soffit of the slab. [redacted]

3.4 Pipe Penetrations

Drainage pipes in the building and car park were in very poor condition, with numerous leaks, discontinuous downpipes and extensive corrosion. Structural elements at some pipe penetration locations were damp. Some pipes were rectangular in shape and were connecting to circular pipes.

3.5 Interface of NCP Car Park and Bus Station

A non-load bearing block wall connected the bus station gym wall and NCP car park brick wall. Lead flashing to the gym roof has been chased into the adjacent NCP car park brick wall. A gap of 60 mm between the bus station structure and the NCP car park wall indicates that no structural interaction exists between the two.

3.6 Defect Summary Schedule

The following schedule summarises the defects identified during the inspection:

Location	Defect	Possible cause	Reference
Car park slab (close to the red column)	Spalling of concrete with exposed rebar.	Paving works carried out above car park reinforced concrete slab. Water ingress through slab	[redacted]
Car park beam (secondary beam close to the red column)	Spalling of concrete with exposed rebar	Unknown	
Car park beam (main beam close to the red column)	Spalling of concrete with exposed rebar	Unknown	
Car park column	Efflorescence on column	Water ingress through slab	
Car park beam	Efflorescence on beam	Water ingress through slab	
Car park slab	Efflorescence on underside of slab	Water ingress through slab	
Car park slab	Damp	Water ingress through slab	
Beams	Crack	Unknown	
Pipes, hopper and joints	Water leaks found	Loose pipe components	
Pipes	Pipe penetrations with efflorescence.	Water ingress	
Pipes	Corroded pipe with water leaks	Water ingress	
Holes in slab	Holes in slab	Water ingress	
Bearing	Rusted bearing	Water ingress	
Slab joints	Efflorescence on slab joints/water leaks	Water ingress	
Car park beam at entrance	Damp	Water ingress	
Building at car park entrance	Damp	Water ingress	
Bus station building stairs	Damp	Water ingress from soffit of slab	

4.0 Summary and Conclusion

The car park structures was found to be in generally fair condition, with a combination of defects of varying severity.

Defects pertaining to quality of construction were apparent in a number of locations, with spalling due to insufficient provision of cover to steel reinforcement. The majority of these defects are minor and do not warrant repair.

There are two notable areas of defective concrete; one beneath the western concourse entrance, where falling concrete was recorded prior to the procurement of the inspection, and the other within the fire escape to the south-west fire escape, adjacent to the [redacted] Both these defects should be address in the near future.

The beams and columns of the car park were generally in good condition with some visible hairline cracks, that should be monitored as part of future inspections.

Construction joints throughout the slab were in generally good condition, with a small number of areas where voids were apparent, presenting the potential for passage of water.

Defects relating to the management of water through drainage and waterproofing to the slab, were prevalent throughout the structure. Defects to drainage has resulted in widespread water leakage, and subsequent corrosion to ancillary steelwork (underslung drainage, ducting and the associated bracketry).

Efflorescence on the underside of the slab and on the beams were likely caused by water ingress through the slab, due to localised failure of waterproofing. It is noted that surfacing to the bus depot and associated waterproofing to the concrete slab, were in the process of being replaced at the time of inspection. Long term ingress of water to the reinforced concrete, particularly where deicing salts are used around the interchange, increases the risk of corrosion to steel reinforcement and subsequent spalling.

Around openings in the concrete slab for the stairwells between the concourse level and car park, water leakage is apparent around the openings, indicating a lack of upstand and associated waterproofing to prevent it. Additionally, there are a number of areas of leakage to the concourse building that require further investigation and remediation.

Despite the prevalence of water leakage there is limited evidence of corrosion products to areas of reinforced concrete.

5.0 Recommendations

The following recommendations are made to address defects observed during the inspection:

- Remedial works to address defective concrete to the slab soffit, beneath the west concourse entrance and at the south-west stairwell opening.
- Remedial works to address cracking to main beams, incorporating resin injection to minimise potential ingress of water.
- Remedial works to address voids in construction joints, incorporating use of suitable repair material to minimise potential ingress of water.
- Repairs to superstructure waterproofing, to minimise water ingress through the concrete slab.
- Defective superstructure drainage should be replaced, [redacted]
- Routine maintenance to clear superstructure drainage, including gullies around the interchange and pipework beneath the slab.
- Provision of an upstand around stairwell openings to slab to prevent water ingress.
- Routine maintenance to clear roof gutters and downpipes throughout concourse building.
- Louvred openings to concrete slab should be replaced to minimise ingress of water.
- Monitoring of minor defects as part of future inspections.

The following further recommendations are made to provide a comprehensive understanding of the current condition and inform the future management of the structure:

- Completion of a condition survey to incorporate a suite of concrete testing, including carbonation, chloride and sulphate sampling, cement content and half-cell testing.
- Investigation into areas adjacent to the south-west of the car park [redacted] to establish any structural interaction.
- Consideration should be given to undertaking an assessment to establish the capacity of the structure, with a suitable allowance made to account for the current condition.
- Completion of a safety inspection at an interval of approximate 6 months
- Consideration should be given to exposing the structural elements of the floor construction to the concourse building, to facilitate further investigation.
- Removal of cladding to building columns to facilitate further investigation.
- Completion of a ground-level visual inspection annually and touching-distance (at height) visual inspection every four years.to promote timely identification of defects.
- Completion of an asbestos management plan to inform the identification of asbestos containing materials.

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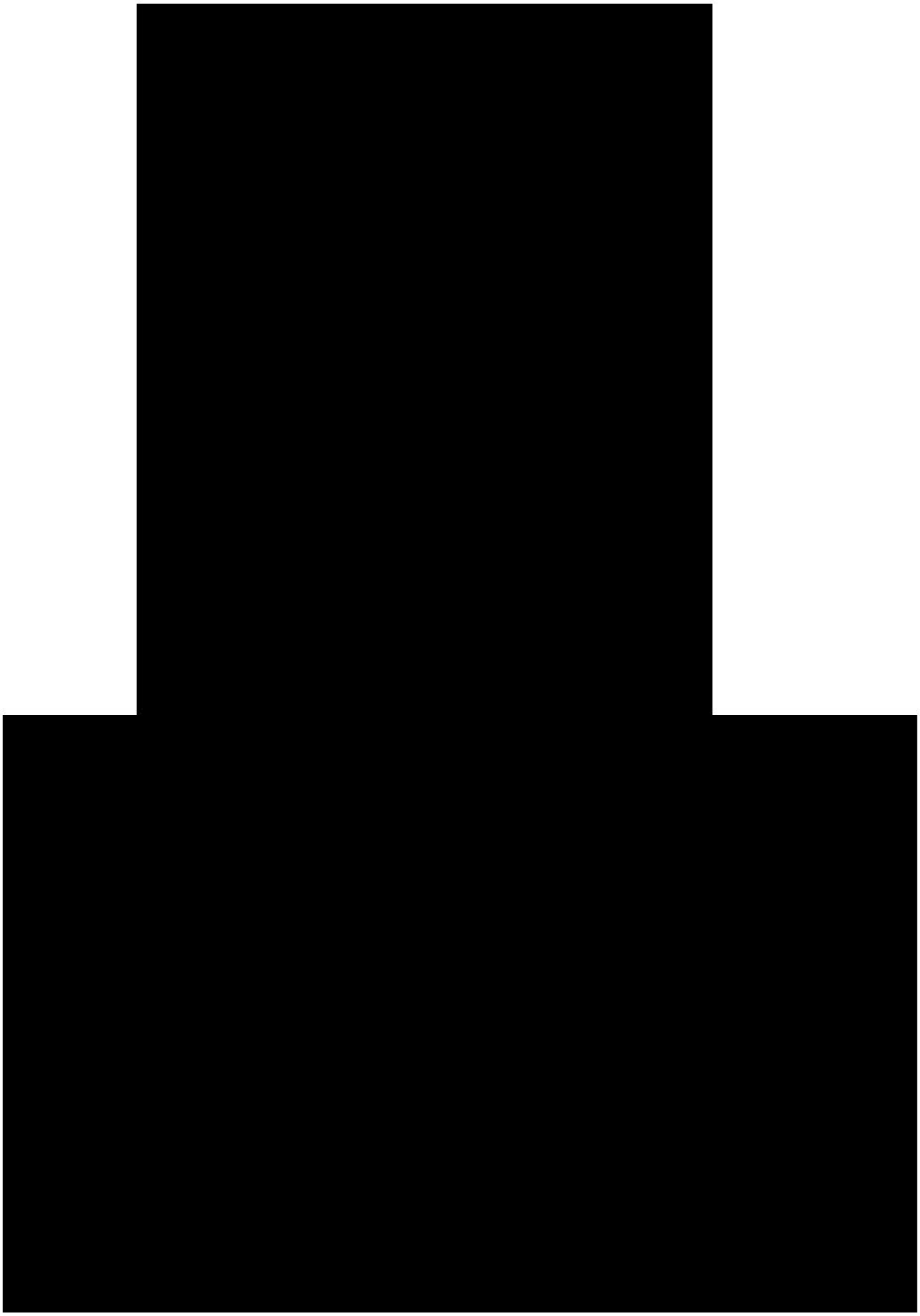
Appendix A - Photographs

[redacted]

[redacted]

[redacted]



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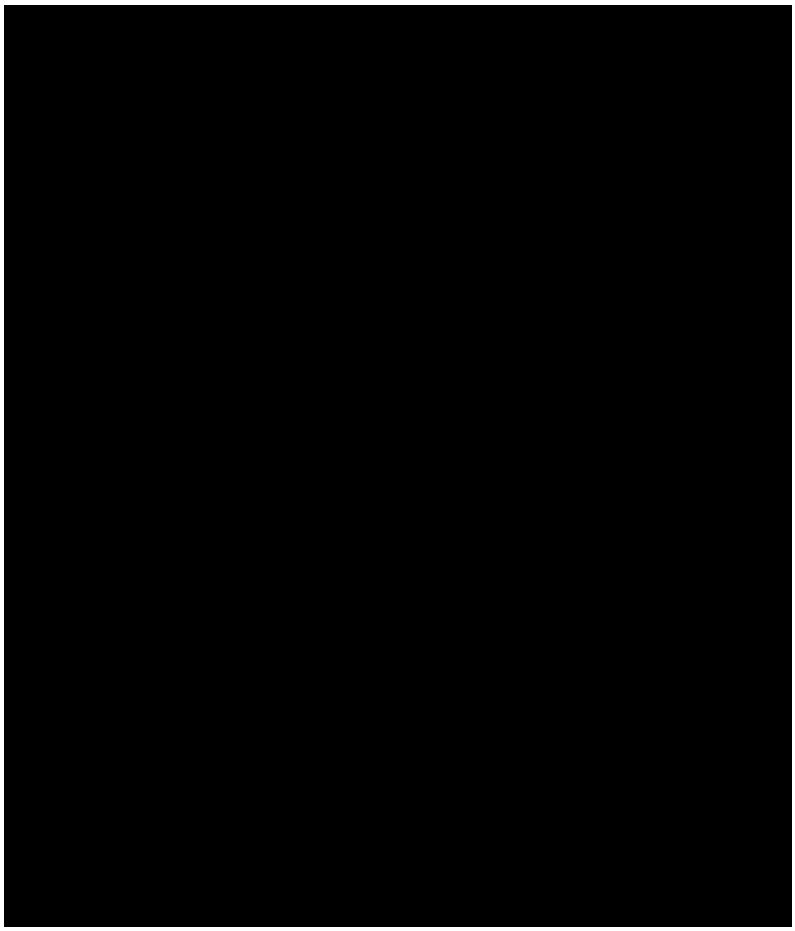

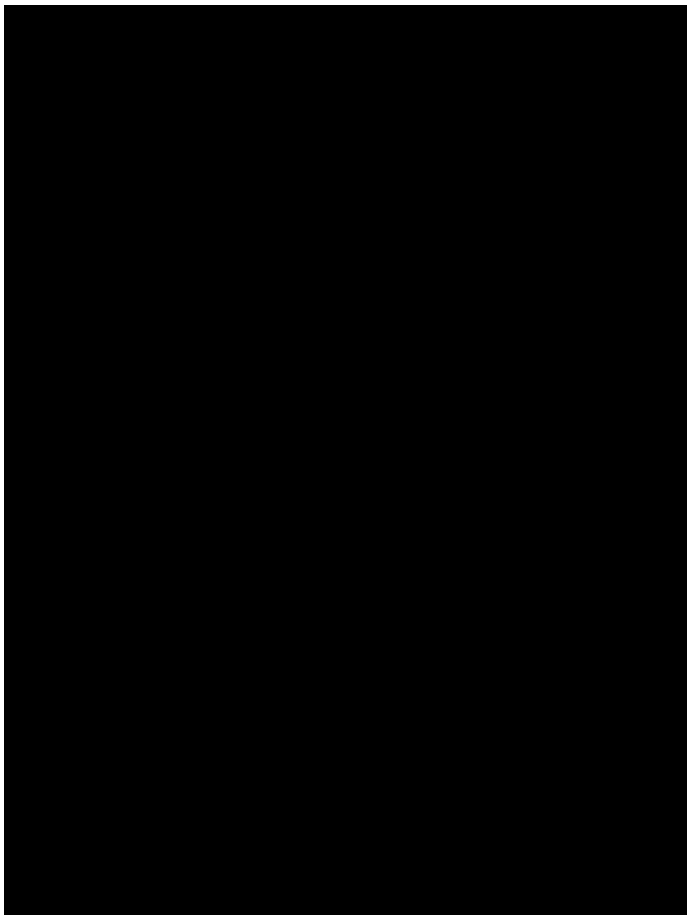

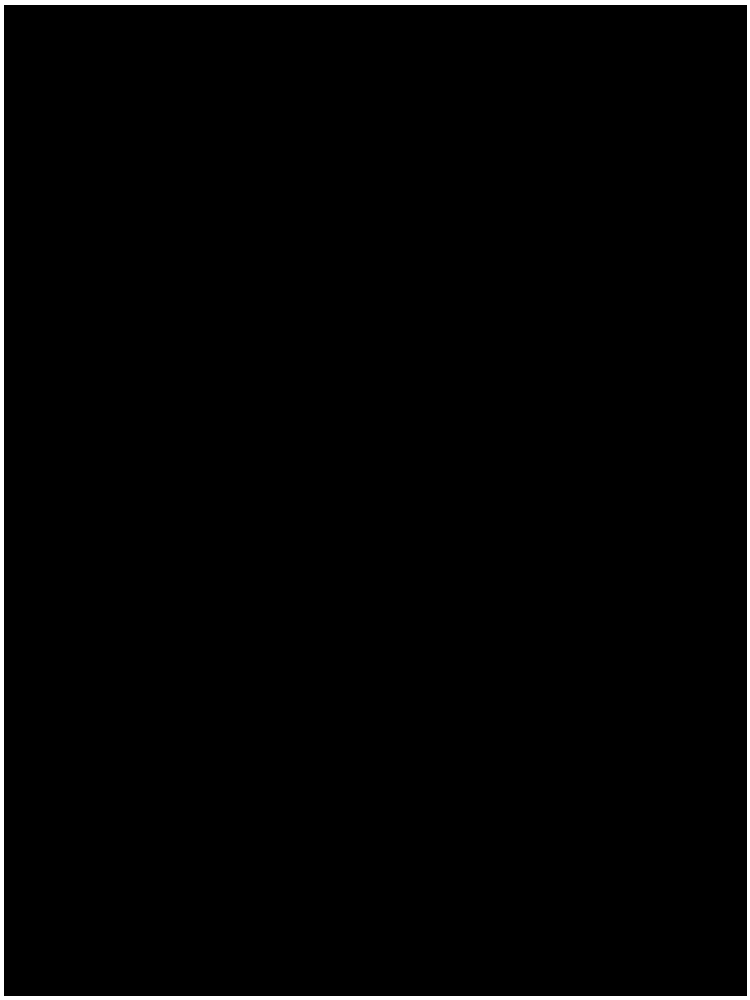

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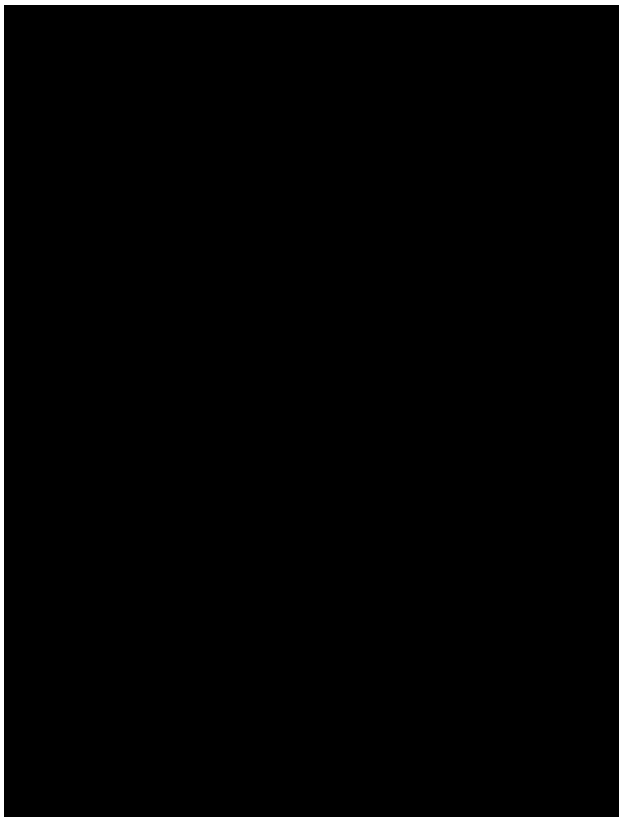

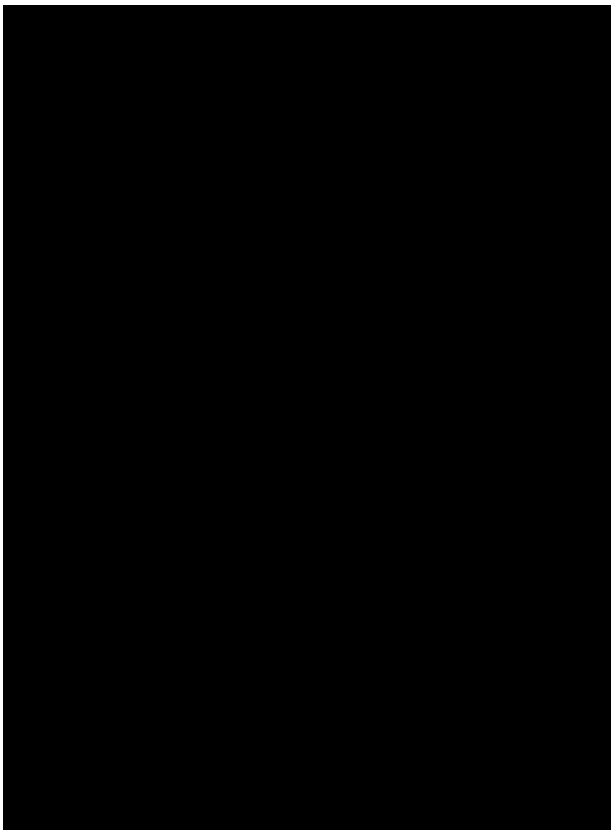

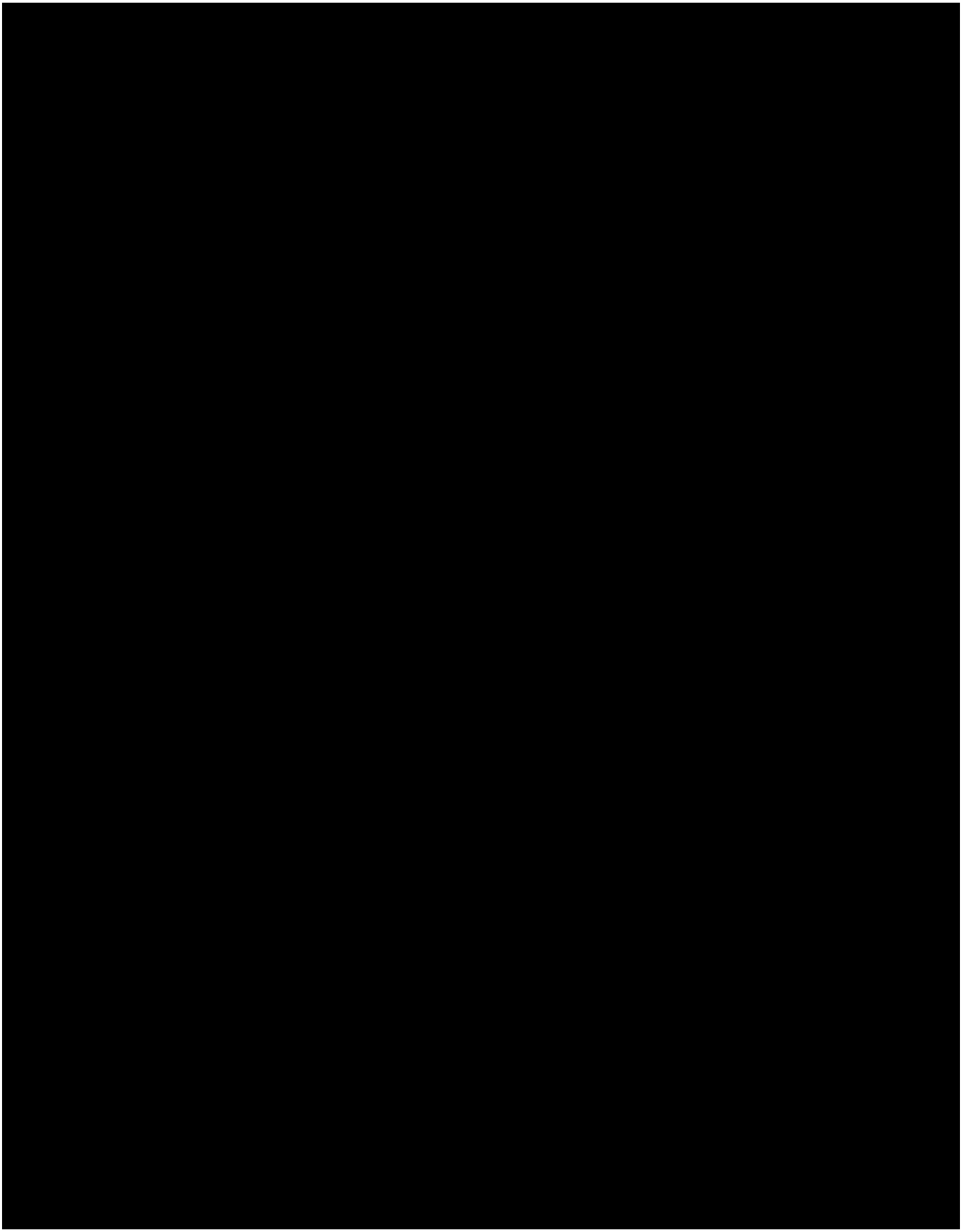

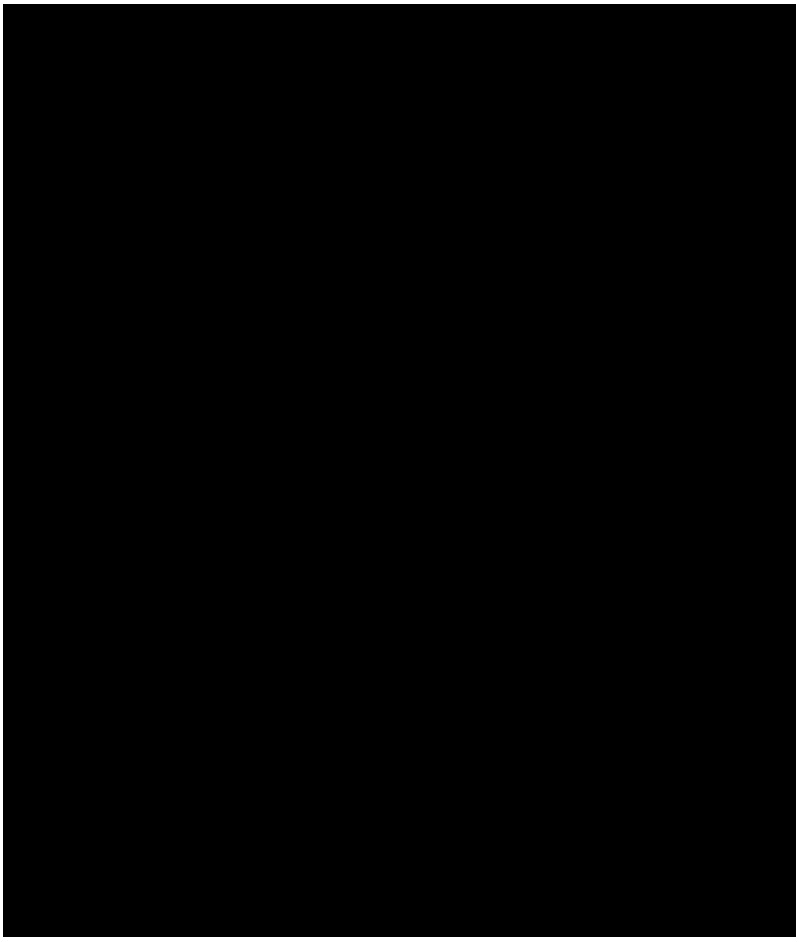

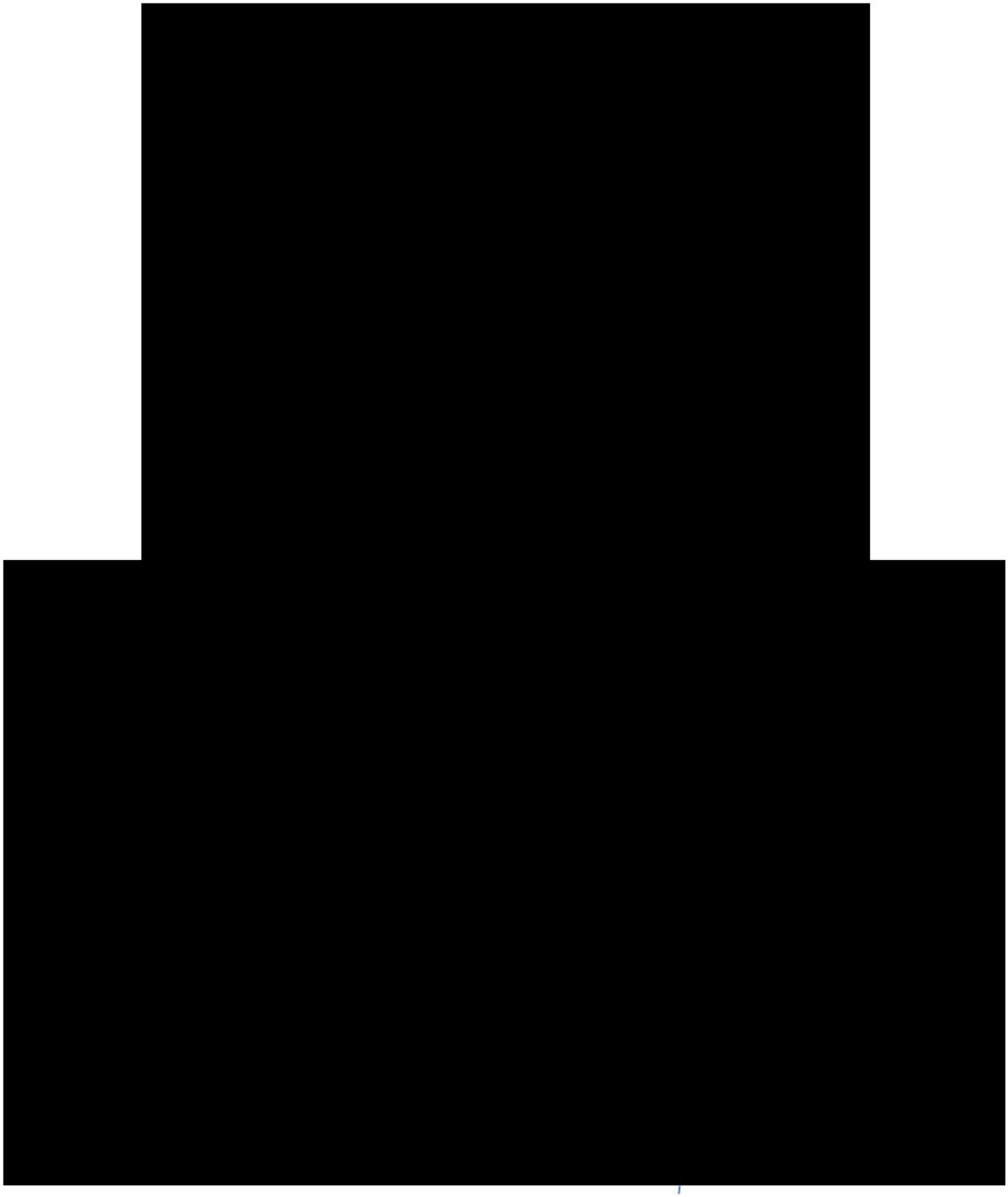

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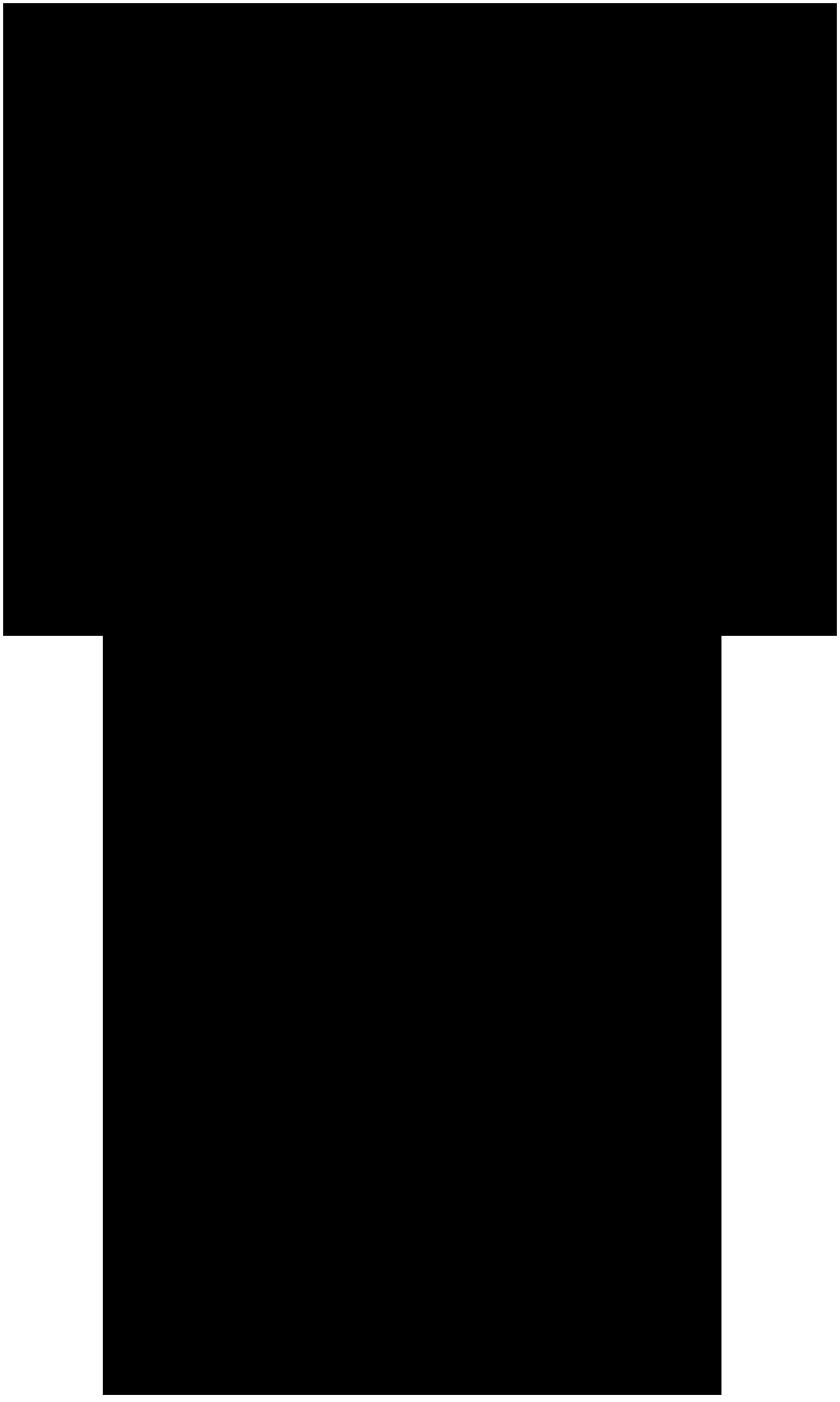

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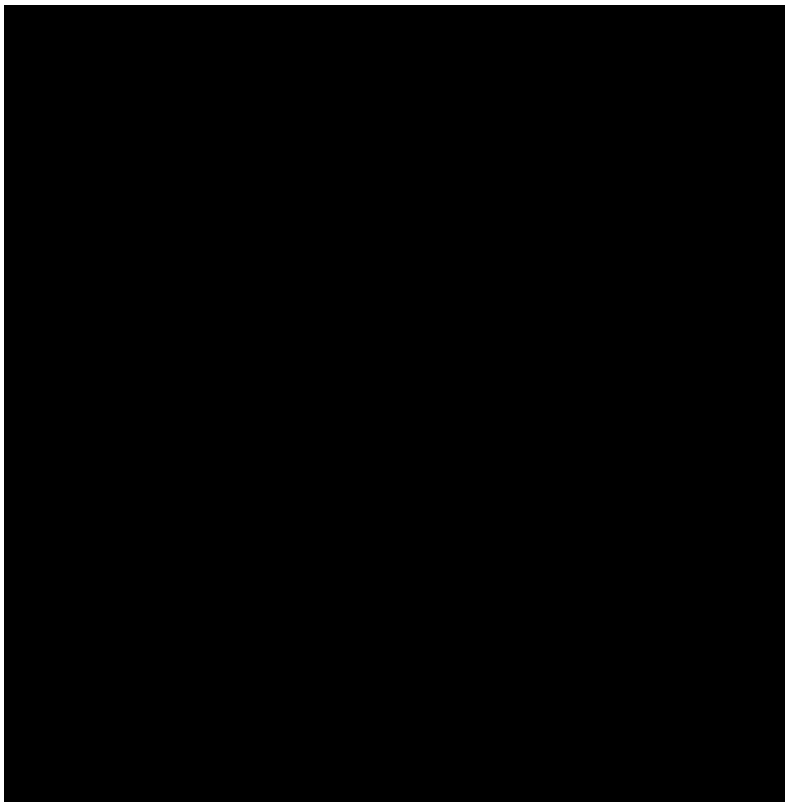

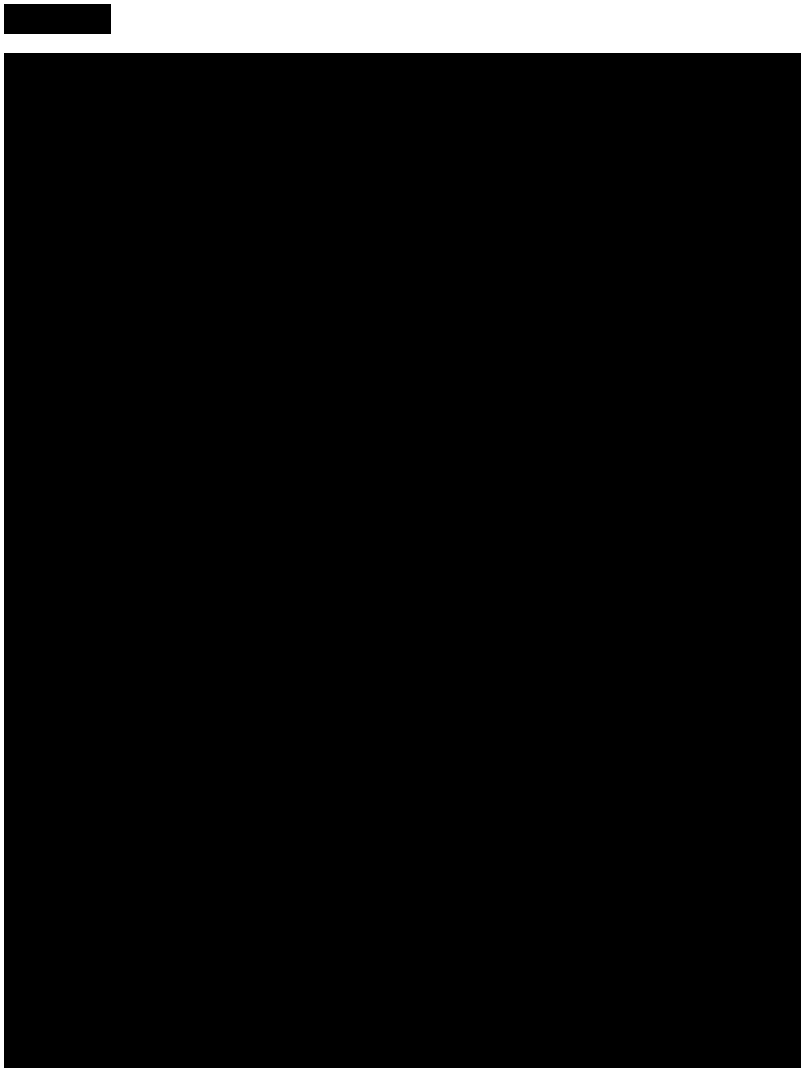

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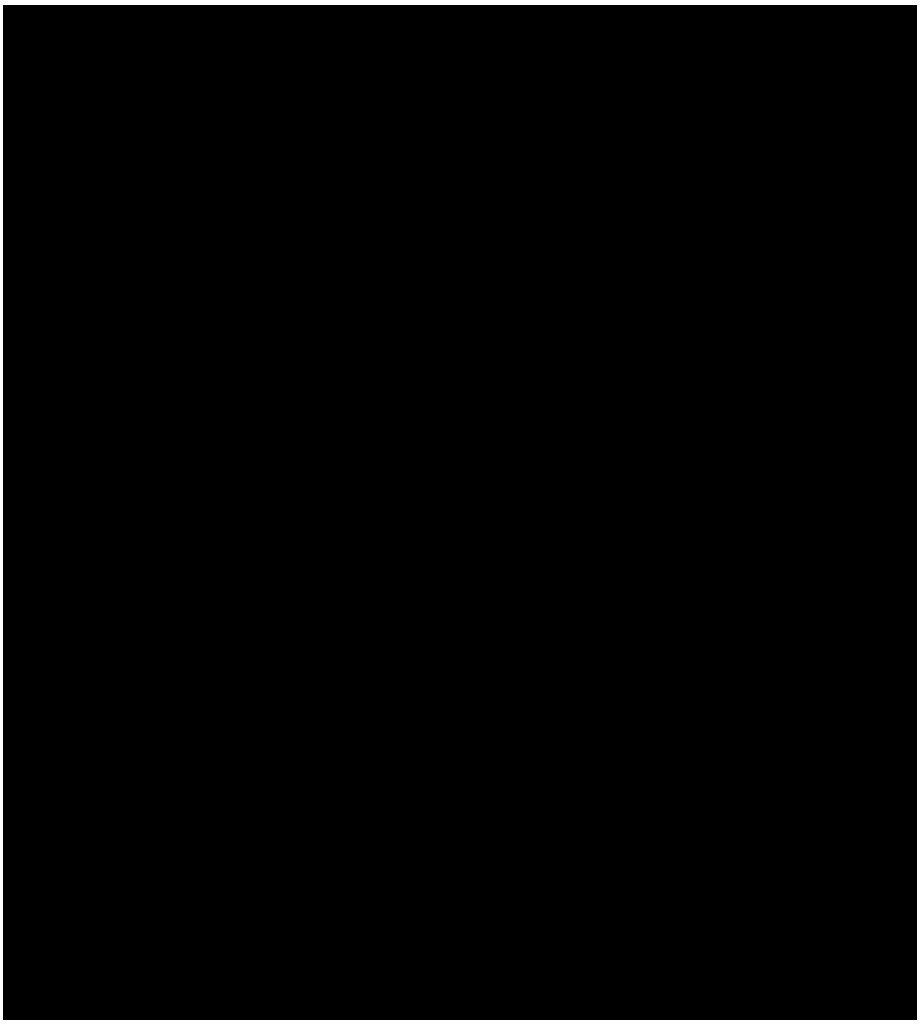

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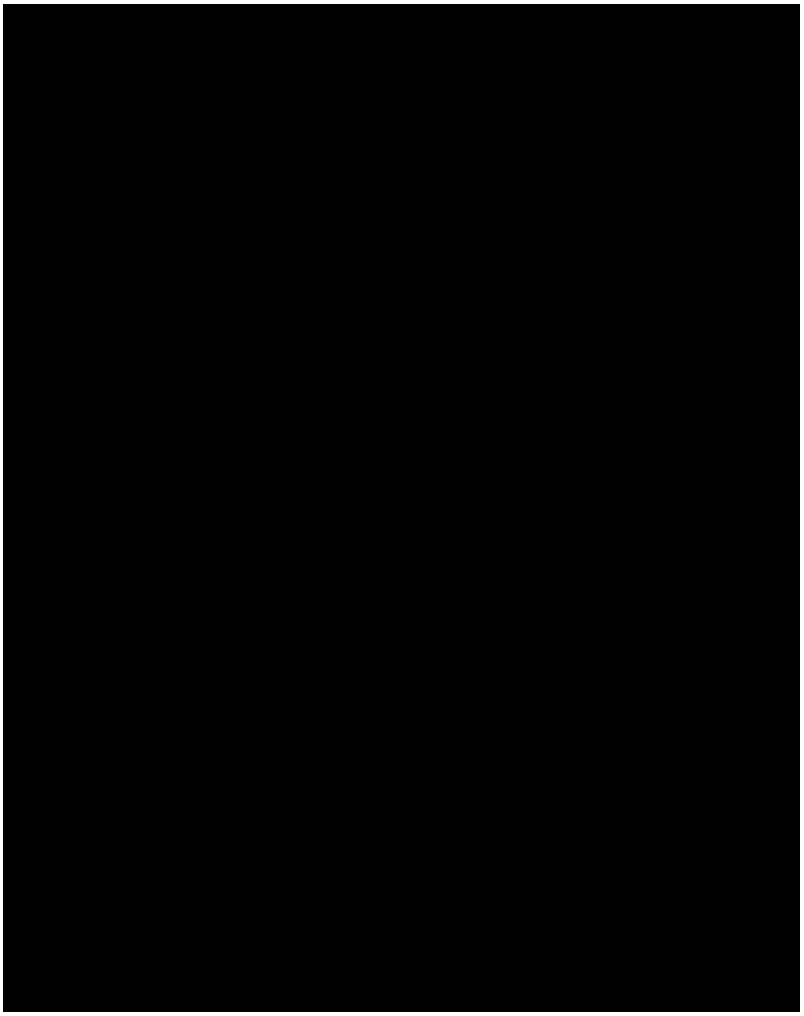
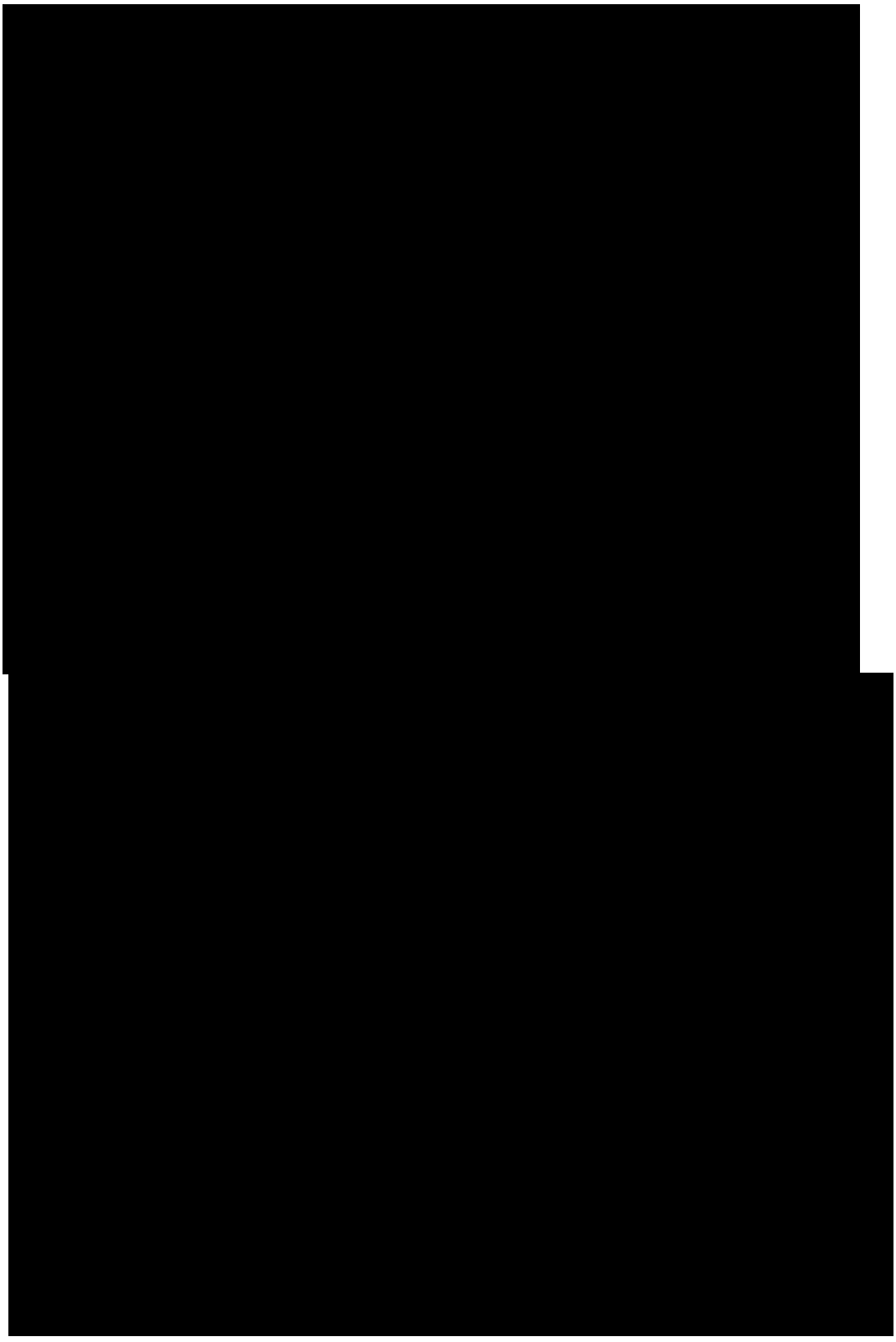


Photo 90- Cracks in tarmac surface



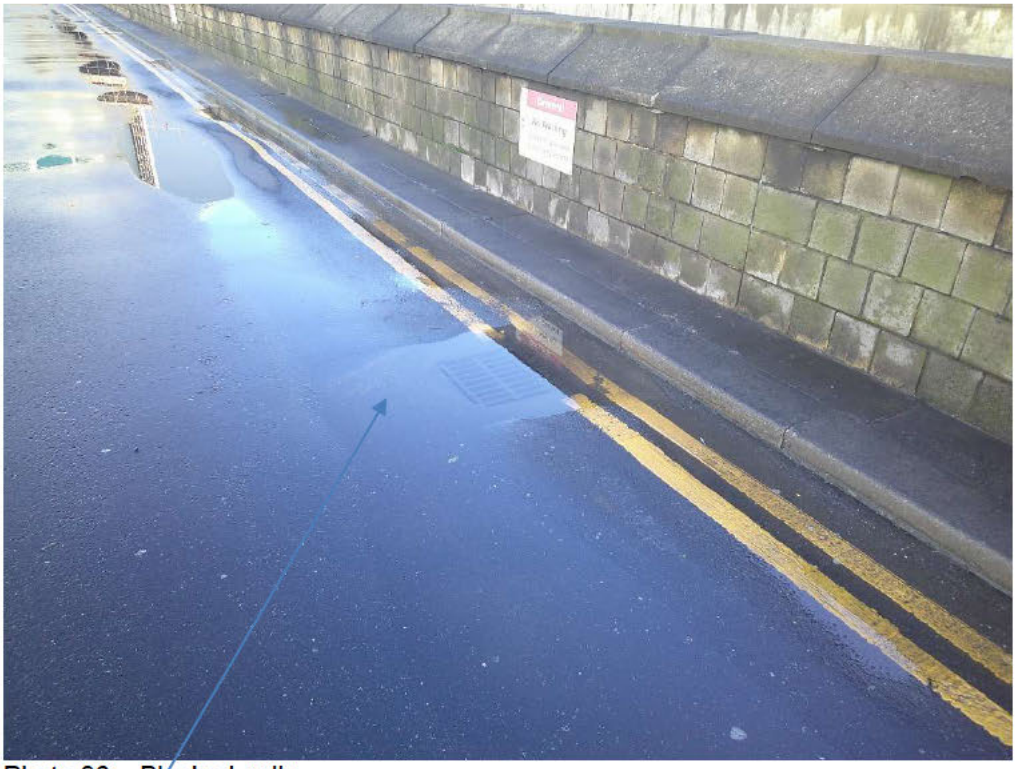


Photo 96 – Blocked gully

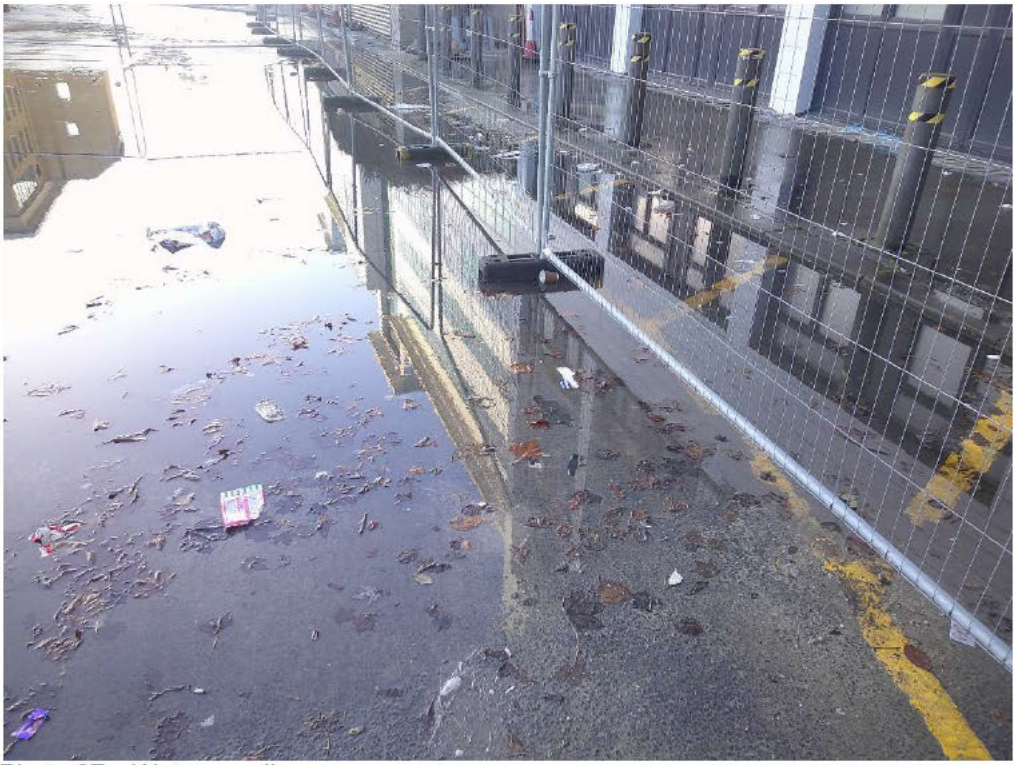
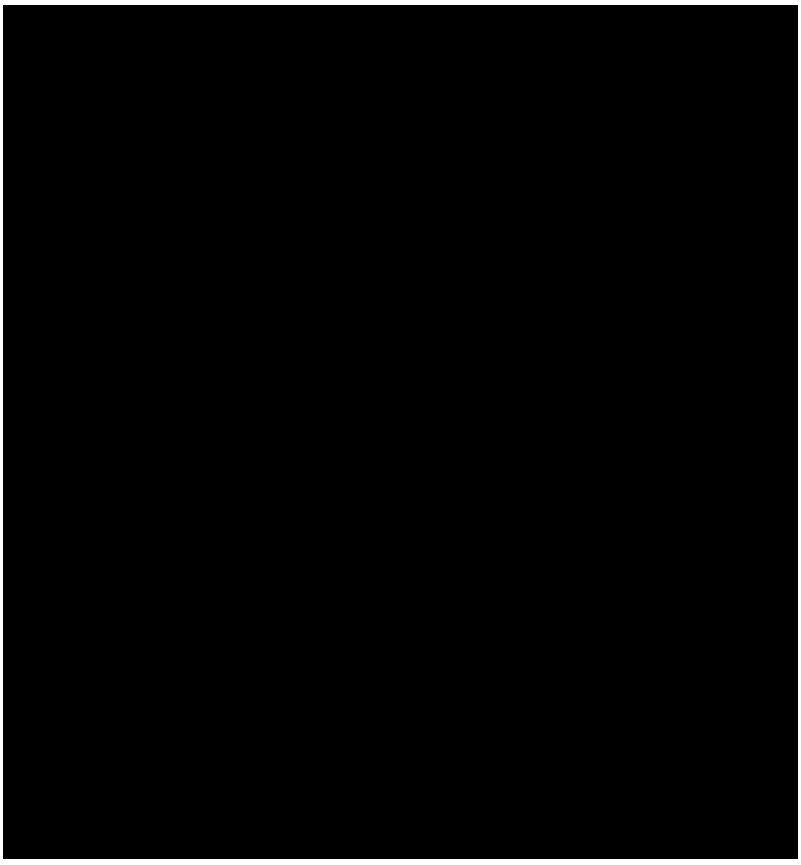


Photo 97 – Water ponding



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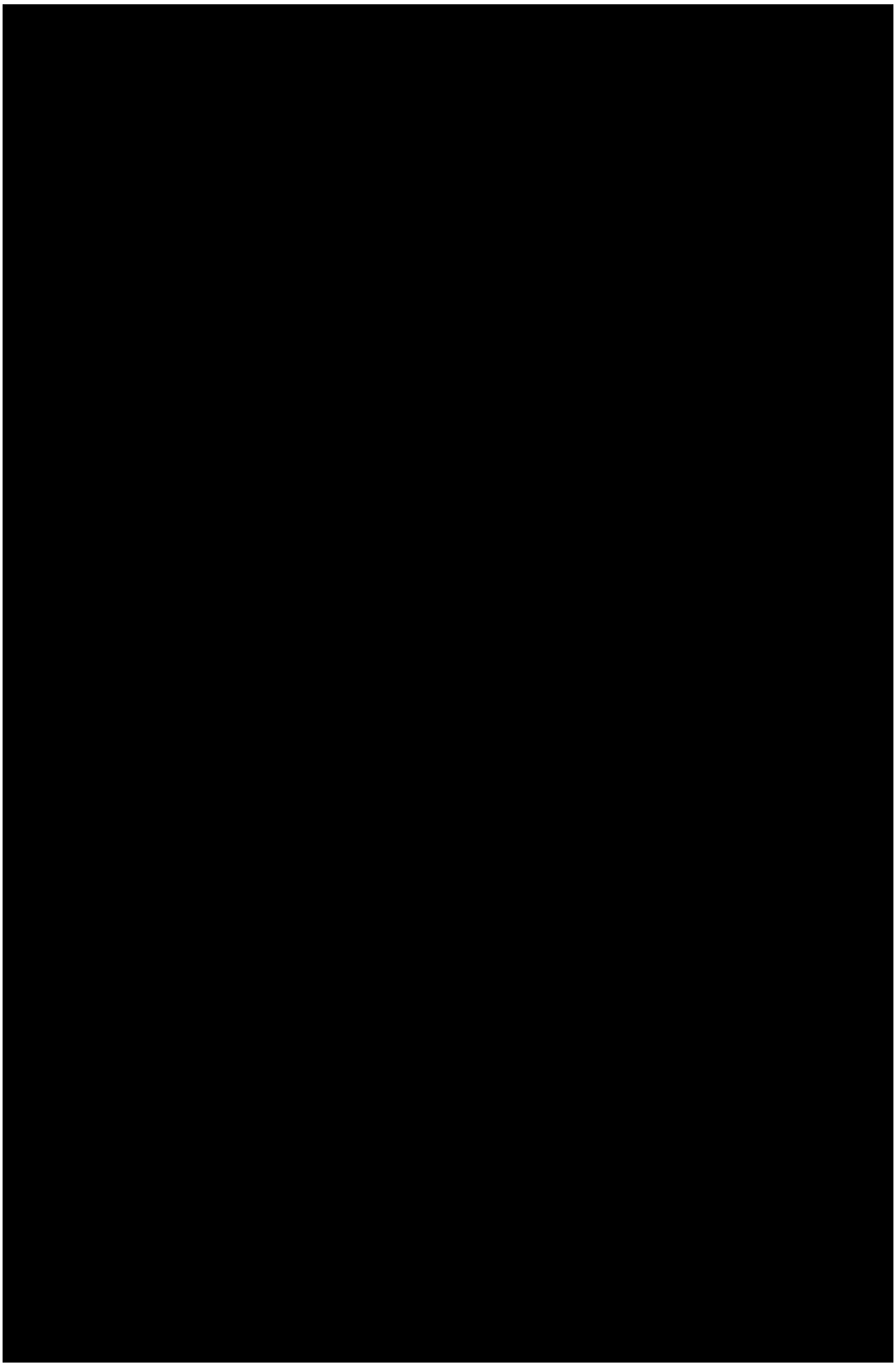

Appendix B – Defect Sketches

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS STATED OTHERWISE.
2. SITE SURVEYS WERE CARRIED OUT ON 12TH, 24TH - 26TH JANUARY AND 9TH FEBRUARY 2024.

Rev	Rev. Date	Purpose of revision	Drawn	Checkd	Rev'd	Apprv'd
-	-	-	-	-	-	-
A	27/02/2024	ISSUED FOR REVIEW	NL	DA	DA	AD

Client

WEST YORKSHIRE COMBINED AUTHORITY

Designer

Jacobs
Cottons Centre, Cottons Lane,
London, SE1 2QG
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Project

STRUCTURAL ASSESSMENT OF
BRADFORD INTERCHANGE BUS STATION

Drawing title

BRADFORD INTERCHANGE UNDERGROUND CAR PARK SLAB

PLAN

Drawing status

ISSUED FOR REVIEW

Scale	1:250	DO NOT SCALE
Jacobs No.	B2382824	Rev A
Client no.	–	

Drawing number

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NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS STATED OTHERWISE.
2. SITE SURVEYS WERE CARRIED OUT ON 12TH, 24TH - 26TH JANUARY AND 9TH FEBURARY 2024.

LEGEND	
⊠	GULLYS/PIPE PENETRATION
⊗	DISCONNECTED DRAIN PIPE
○	DRAINAGE PIPE
☒	RECTANGULAR HOLE
□	COLUMN
╲╱ ╱╲	SLAB GENERALLY IN GOOD CONDITION

SLAB DEFECTS	
①	WHITE PATCH
②	DAMP
③	CRACK
④	WATER LEAKS FOUND
⑤	EXPOSED REBAR/SPALLING OF CONCRETE
⑥	PIPE PENETRATION - WHITE PATCHES
⑦	CORRODED PIPE
⑧	HOLE
⑨	RUSTY BEARING
⑩	JOINT WATER LEAK/WHITE PATCH

-	-	-	-	-	-	-
A	27/02/2024	ISSUED FOR REVIEW	NL	DA	AD	SM
Rev	Rev. Date	Purpose of revision	Drawn	Checkd	Rev'd	Apprv'd

Client

WEST YORKSHIRE COMBINED AUTHORITY

Designer

Jacobs
Cottons Centre, Cottons Lane,
London, SE1 2QG
www.jacobs.com

Project

STRUCTURAL ASSESSMENT OF
BRADFORD INTERCHANGE BUS STATION

Drawing title

BRADFORD INTERCHANGE UNDERGROUND CAR PARK SLAB

LOCATIONS OF DEFECTS

Drawing status

ISSUED FOR REVIEW

Scale	1:250	DO NOT SCALE
Jacobs No.	B2382824	Rev A
Client no.	–	

Drawing number

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Appendix C – Existing Record Drawings

[redacted]

[redacted]

[redacted]

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- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Appendix E – Indicative Repair Methodology and Data Sheets

Indicative Repair Methodologies

Slab Soffit (below west entrance to concourse building)

1. Area of repair to be 1.2 m x 1.2 m (see Photo 65).
2. Contractor to carefully break out concrete in the specified area and expose the bottom reinforcement.
3. Contractor to confirm that there are no vertical cracks in the slab.
4. Contractor is to brush reinforcement and apply NATCEM 35 in accordance with manufacturer's specifications.

Slab Joints (general)

The joint is to be filled with QUIKRETE in accordance with manufacturer's instructions.

Slab Joints (Lower Concourse)

Joint between wall and slab to be sealed with QUIKRETE. Source of water from above in the Santander area should be investigated.

Natural Cement

PRODUCT SHEET
Issue Date: June 2017

NATCEM 35

Description

NATCEM 35 is a fast setting and fast curing mortar with a rapid strength gain that is resistant to chloride penetration, consisting of a blend of NATCEM Reg.31 Cement Binder, specially selected dried graded aggregates all passing a 2mm sieve and retarders.

Uses

- Waterproof renders
- Work in and around sewers
- Industrial floor repairs
- Work in food factories
- Concrete repair
- Work in and around the sea
- Animal sheds and silage pits
- Garage pits
- Basement tanking
- Farm yards and cess pits
- Pipe joints and benching
- Sealing garage pits
- Fast general repairs and construction work
- Work wherever pollution or chemical attack is likely
- Overhead and horizontally
- Setting holding down bolts
- Floor screeds
- Bedding blocks
- Stone and bricks
- In contact with potable water
- Fine moulding.

Properties

- Fast setting
- Excellent adhesion
- Low shrinkage
- Low modulus of elasticity makes it very effective on poor or friable substrates
- Excellent resistance to pure water and sulphated water
- Excellent resistance to aggressive chemicals
- Very good cohesion and mixing
- Fine compact surface
- No curing necessary. It can be coated, covered or painted as soon as setting is complete
- Can be used in wet conditions
- Can be used under water
- High Strength
- Low carbon dioxide permeability
- Low water permeability.

NATCEM 35

Method of use

Preparing the surface

Do not use on frozen or over heated substrates (Outside the range of 0°c-30°c). Prepare the surface in advance to provide an adequate key. On glazed brickwork the joints should be raked out and the surface bush hammered to form a key. The surface to which the NATCEM 35 is applied should be clean, free from dust and thoroughly dampened. Where necessary steel or aluminium mesh can be used. Ensure that a 10mm minimum thickness of material is obtained.

Priming

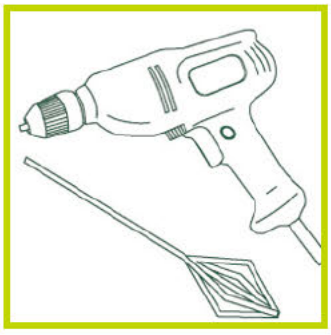
There is no need to prime any reinforcement, but if priming is preferred, any conventional system may be used.

Application

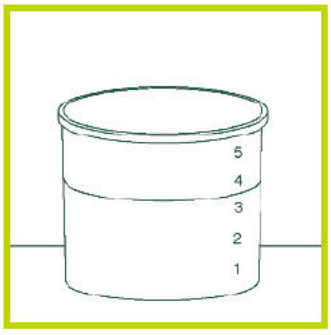
Mixing

For optimum results, mix using conventional mixing machines. Always place the water in the mixer or mixing container and add the powder. Gradually add the NATCEM 35 to no more than 3.6 litres of clean water per bag whilst continuously mixing the material. If one bag or less is to be used the NATCEM 35 can be mixed with a rose bud type paddle attached to an electric drill (900rpm, 1000w). Mix vigorously for at least 2 minutes after adding all the mixture to the water. NATCEM 35 is designed to give a fluid mix but this only develops after sufficient mixing. The mix will appear dry at first. Continue mixing until fluidity develops. If greater fluidity is required, more water up to a total of 4 litres may be used. Exceeding this ratio will lead to lower strength, longer setting time and the risk of surface cracking appearing. In cold weather the set can be accelerated using warm water, likewise in hot weather cold water can be used to slow down the set.

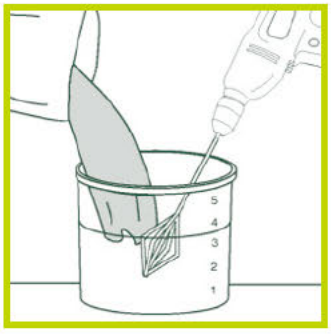
One bag



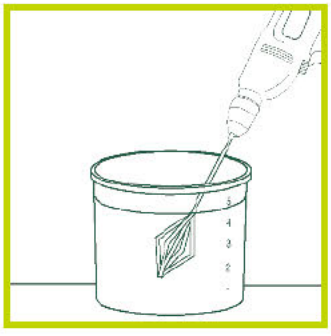
Rose bud paddle in electric drill 900rpm 1000w.



Place 3.6 litres of water into a container.



Add the Natcem 35 to water mixing all the time.



After the NATCEM 35 has been added mix for at least 2 minutes.

General

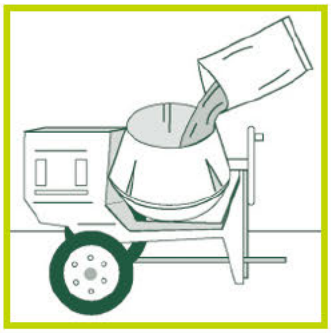
After mixing, apply the material as quickly as possible after mixing using traditional tools. A 10mm minimum thickness of the material is always necessary. Do not apply additional water to the surface during finishing as this may cause surface cracking. Once setting has started DO NOT attempt to remix or to smooth the surface. This will cause the mechanical properties, in particular strength and adhesion to be lost.

Tanking

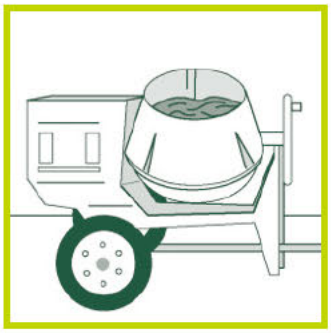
Prepare the walls and floor which are to be treated by removing all paint and surface coatings. Cut a chase a minimum of 10mm deep by 10mm wide at all internal angles of the wall to wall and wall to floor joints, then fill with NATCEM 35 as the work proceeds. Form fixing points by cutting out an area at least three times the diameter and one and a half the length of the fixing, filling with the NATCEM 35 as work proceeds but clearly marking the position. Well dampen the surface with water but ensuring no standing water. Mix the NATCEM 35, well dampen the surface again with water, carry out the rendering of the walls using standard and accepted techniques ensuring at all times a minimum thickness of 10mm. Protect against direct sunlight or wind until the setting has completed. Once the NATCEM 35 has set, allow at least 1 hour before applying any surface coatings or covering to the walls or to the floors.

More than one bag

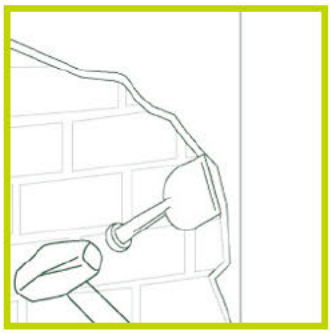
Add water to the mixer at a ratio of 3.6 litres per bag of NATCEM 35.



Gradually add the NATCEM 35 to the mixer.

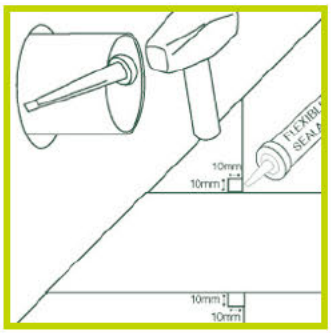


After adding all the NATCEM 35 mix continuously for at least 2 minutes at medium speed.

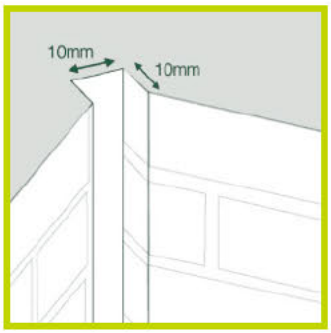


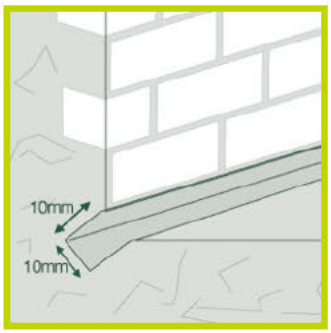
Prepare surface, remove paint, coatings, renders and plaster.

Stop any running water with NATCEM Waterstop. (See separate leaflet)

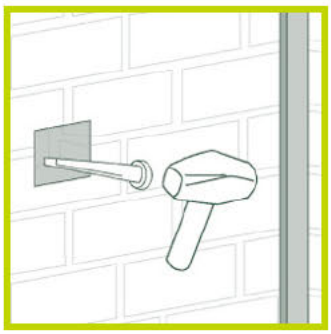


Cut a rebate around any pipe or cable and fill with sealant to form flexible seal around pipe or cable.

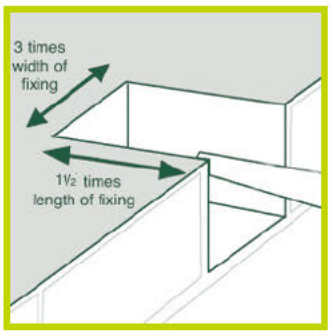


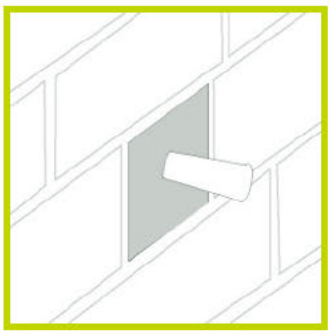


Form chase at wall to floor and all internal wall angles minimum 10mm x 10mm.

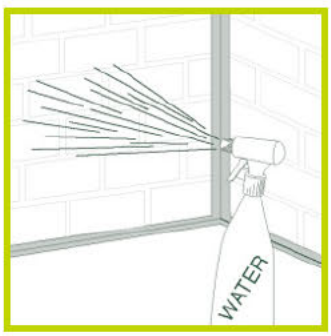


Cut out for fixing point.

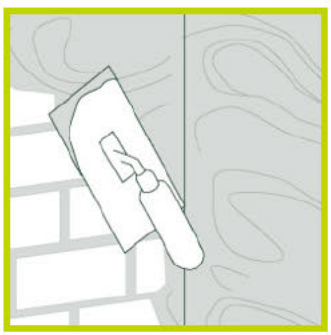




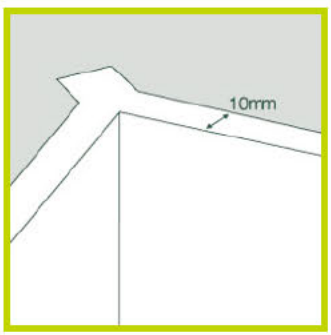
Fill fixing points and clearly mark.



Well dampen surface with water ensuring no standing water.



Apply material to wall.

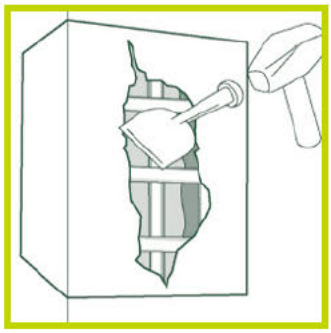


Ensure at all times a 10mm minimum thickness.

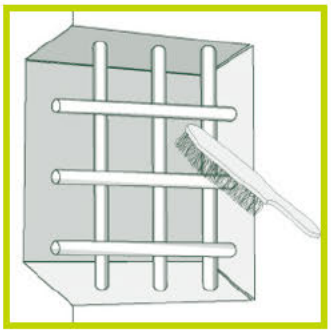
NATCEM 35 is a fast setting and fast curing mortar with a rapid strength gain that is resistant to chloride penetration, consisting of a blend of NATCEM Reg.31 Approved Cement Binder, specially selected dried graded aggregates all passing a 2mm sieve and retarders.

Concrete repairs

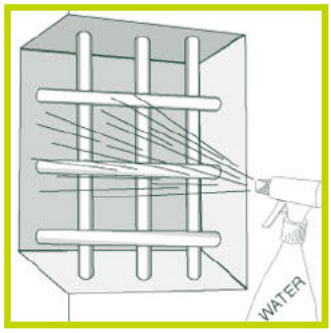
Remove all loose material from the concrete and the reinforcement. It is only necessary to remove the loose rust from the reinforcement. Prepare the surface as described previously. Fix any necessary replacement reinforcement and formwork. Well dampen the surface with water ensuring there is no standing water. Mix the material, dampen the surface again and then apply the NATCEM 35 as previously recommended ensuring that the NATCEM 35 is worked around the reinforcement. Ensure a minimum thickness of material of 10mm at all times. Protect the surface from direct sunlight or wind until setting has completed. Once the NATCEM 35 has set allow at least 1 hour before applying any surface coatings or covering.



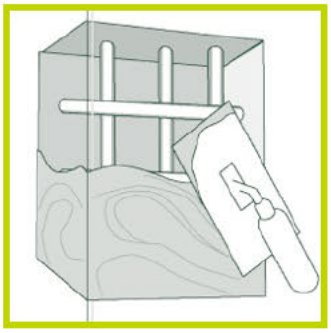
Cut back loose and spalling concrete a minimum depth of 10 mm.



Wire brush any reinforcement to remove any loose rust.



Well dampen the concrete with water ensuring no standing water.



Mix NATCEM 35 as instructed and place the mortar, ensuring at all times a minimum thickness of 10mm.

Setting times

NATCEM 35 is designed to commence setting at 35 minutes and finish setting at 40 mins at 20°c. In winter NATCEM 35 can be used down to 0°c. The set will be slower but can be accelerated by using warm water. In very hot temperatures the set will be faster and can be slowed by using cold water.

Surface Coating Natcem35

When applying finishing plaster to NATCEM 35 we would recommend using Thistle Board-Finish Plaster and not Thistle Multi-Finish

Cleaning
Clean all tools with water immediately after use.

Storage
NATCEM 35 is packaged in a polythene inner bag with a re-sealable tie within a stitch sealed woven polypropylene outer bag that should be stored in dry conditions and will last for at least twelve months.

Yield
Generally 1 x 25kg bag of NATCEM 35 mixed with 3.6 litres of water will produce 10 litres of finished mortar.

How to specify
NATCEM 35 shall be mixed and applied to prepared surfaces all strictly in accordance with the manufacturers instructions.

Precautions
We strongly recommend the use of GLOVES, GOGGLES and MASK. Full details are given on a separate sheet.

Approved for use in public water supplies. Reg.31 Approved
Issue no. 26th June 2017

Setting time & strength gain

Start Set End Set	35 Min 40 Min	at 20°c at 20°c
	Flexible Strength (Mpa)	Compressive Strength (Mpa)
1 Hour	2.2	9
3 Hours	2.5	16
24 Hours	3	21
7 Days	4.8	29
28 Days	7	50
Strength continues to develop thereafter.		

Conforms with the requirements of EN1504-3 CLASS R4

ISO 14001 ENVIRONMENTAL MANAGEMENT

Distributed by:

Natural Cement

ISO 9001 QUALITY MANAGEMENT

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