Establishing and quantifying the causal linkage between drainage and earthworks performance for Highways England

Matt Lane

Ground related risk to transportation infrastructure

The Geological Society

26 October 2017
Earthwork and drainage assets
## Data sources

<table>
<thead>
<tr>
<th>Data</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>HE National earthworks inventory and condition</td>
<td>HAGDMS (HE / Mott MacDonald)</td>
</tr>
<tr>
<td>HE National drainage inventory and condition</td>
<td>HADDMS (HE / Mott MacDonald)</td>
</tr>
<tr>
<td>HE National records of earthwork failures and defects</td>
<td>Geotechnical Asset Database (GAD) and Geotechnical Maintenance Forms (GMFs) of HAGDMS (HE / Mott MacDonald)</td>
</tr>
<tr>
<td>HE National records of earthworks repair costs</td>
<td>Geotechnical Maintenance Forms (GMFs) of HAGDMS (HE / Mott MacDonald)</td>
</tr>
<tr>
<td>Earthwork outlines</td>
<td>Ordnance Survey Mastermap Slope Areas</td>
</tr>
</tbody>
</table>
HAGDMS – Earthwork inventory and condition
## HAGDMS – Earthwork failure records and repair costs

**Geotechnical Maintenance Form: Part A**

| Area: | 3 |
| Unique defect ID: | M4_206_386244 |
| Initial Assessment | Now |
| Defect Class | 1A |
| Location Index | C |
| Feature Grade | 4 |
| Comments: | |
| Emergency works: | Unscheduled |
| Emergency works details: | none |
| Emergency works costs: | £0 |
| Proposed investigation: | 3 window sample holes and 1 trial pit, topographic survey. |
| Proposed investigation date: | 17 Nov 03 |
| Proposed remedial or preventative works: | Granular replacement of failed material |
| Proposed remedial or preventative works estimated costs: | £50,000 |
| Ian Duncan | |
| Date Part A sent: | 06 Apr 04 |
| Date Agreement required by: | 16 Apr 04 |
| Oo Geotechnical Advisor technical agreement in principal: | Agreed |
| David Patterson | |
| Date Part A sent: | 08 Apr 04 |
| Comments | Ensure budget agreed with Oo and that all remedial solutions explored. |
| Oo Agreement proceed with investigation: | Agreed |
| Peter Scott | |
| Date Part A sent: | 08 Apr 04 |
HADDMS – Drainage inventory and condition

Network coverage - drainage asset data over time

Inventory

Condition

% network coverage

Month

Network coverage - drainage asset data over time
## Drainage Condition - Structural

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No defects</td>
</tr>
<tr>
<td>2</td>
<td>Superficial defects</td>
</tr>
<tr>
<td>3</td>
<td>Minor defects</td>
</tr>
<tr>
<td>4</td>
<td>Major defects</td>
</tr>
<tr>
<td>5</td>
<td>Not fit for purpose or unsafe</td>
</tr>
</tbody>
</table>

### Good

### Poor
## Drainage Condition – Service

<table>
<thead>
<tr>
<th></th>
<th>Clear</th>
<th>Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>No capacity loss</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Slight capacity loss</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Severe capacity loss</td>
<td>Poor</td>
</tr>
<tr>
<td>5</td>
<td>Blocked or unsafe</td>
<td></td>
</tr>
</tbody>
</table>
### Drainage condition

<table>
<thead>
<tr>
<th>Structural condition</th>
<th>Service condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>1</strong> No defects</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong> Superficial defects</td>
<td></td>
</tr>
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</tr>
</tbody>
</table>

- Nationally 25% of linear drainage assets (mainly pipes) are Poor
Earthwork failure summary

- 670 earthwork failure records were identified over the 11 year recording period.
Earthwork failure – Watery defect
Earthwork – drainage analysis

- Crest Drainage
- Cutting slope
- Carriageway
- Slope Drainage
- Earthworks failure
- Watery defect
- Toe Drainage
Earthwork – drainage analysis
Earthwork – drainage analysis

Failed EW

OS Slope

Drainage

Pipe_Ref: C003

OS Slope Area: D001

Asset_Ref: B001

OB_ID: A001

Carriageway

OB_ID: A005

Pipe_Ref: C004
Earthwork – drainage analysis

Failed EW

OS Slope

Drainage

Pipe_Ref: C003

OS Slope Area: D001

5m drainage buffer

Asset_Ref: B001

Carriageway

OB_ID: A001

OB_ID: A005

Pipe_Ref: C004
Earthwork – drainage analysis results

Drainage Condition Good (1, 2 or 3)
- 14% Drainage Condition Known
- 86% Drainage Condition Unknown

Drainage Condition Poor (4 or 5)
- 67% Drainage Condition Known
- 33% Drainage Condition Unknown

Drainage Condition Unknown
- 86% Watery Defect
- 16% No Watery Defect

Drainage Condition Good (1, 2 or 3)
- 23% Drainage Condition Known
- 77% Drainage Condition Unknown

Drainage Condition Poor (4 or 5)
- 58% Drainage Condition Known
- 42% Drainage Condition Unknown

Drainage Condition Unknown
- 86% No Watery Defect
- 14% No Watery Defect

Failure with GMF
- 670
Earthwork – drainage analysis results

Drainage Condition
Good (1, 2 or 3)
- 14%

Drainage Condition Known
- 67%

Drainage Condition Unknown
- 33%

% of failures
- 3%

No Drainage
- 16%

Watery Defect
- 22%

Failure with GMF
- 670

Drainage Condition
Poor (4 or 5)
- 86%

Drainage Condition Known
- 84%

Drainage Condition Unknown
- 42%

No Drainage
- 14%

No Watery Defect
- 78%
Earthwork – drainage analysis results

- Drainage Condition Good (1, 2 or 3): 3% of failures, 14% drainage condition known.
- Drainage Condition Poor (4 or 5): 86% of failures, 67% drainage condition known.
- Drainage Condition Unknown: 33% of failures, 84% drainage condition known.
- No Drainage: 3% of failures, 16% drainage condition known.

- Drainage: 22% watery defect.
- No Drainage: 78% no watery defect.
- Failure with GMF: 670.
Earthwork – drainage analysis results

<table>
<thead>
<tr>
<th>% of failures</th>
<th>Drainage Condition Good (1, 2 or 3)</th>
<th>Drainage Condition Poor (4 or 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>14%</td>
<td>86%</td>
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</table>

- Drainage Condition Known
  - Drainage: 67%
  - Drainage Condition Unknown: 33%
    - No Drainage: 3%
    - No Drainage with GMF: 16%

- Watery Defect: 22%

- Failure: 670
  - No Watery Defect: 78%

causal linkage between drainage and earthworks performance – Matt Lane - (c) Mott MacDonald 2017
Earthwork – drainage analysis results

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Drainage Condition Known

<table>
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<tr>
<th>% of failures</th>
<th>No Drainage</th>
<th>Drainage</th>
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<tbody>
<tr>
<td>3%</td>
<td>22%</td>
<td>84%</td>
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Drainage Condition Unknown

<table>
<thead>
<tr>
<th>% of failures</th>
<th>No Drainage</th>
<th>Drainage</th>
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<tbody>
<tr>
<td>3%</td>
<td>16%</td>
<td>22%</td>
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Failure with GMF

670

No Watery Defect

78%

Drainage Condition Good (1, 2 or 3)

<table>
<thead>
<tr>
<th>% of failures</th>
<th>Drainage Condition Poor (4 or 5)</th>
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<tbody>
<tr>
<td>52%</td>
<td>77%</td>
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Drainage Condition Known

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<tr>
<th>% of failures</th>
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Earthwork – drainage analysis results

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<tr>
<td>16%</td>
<td>86%</td>
<td>33%</td>
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</table>

Total % earthworks failures with drainage problems: 74%

Drainage Condition Known

- Drainage: 84%
- No Drainage: 16%

Watery Defect: 22%

Failure with GMF: 670

Drainage Condition Good (1, 2 or 3)

- 23%
- 77%

Drainage Condition Unknown

- 58%
- 86%
- 42%

No Watery Defect: 78%
Earthwork – drainage analysis results

- **Total % earthworks failures with absent or insufficient drainage**: 6%
  - % of failures | Drainage Condition
  - 3% | Good (1, 2 or 3)
  - 16% | Poor (4 or 5)

- **Total % earthworks failures with poor drainage condition**: 68%
  - % of failures | Drainage Condition
  - 23% | Good (1, 2 or 3)
  - 52% | Poor (4 or 5)

Causal linkage between drainage and earthworks performance:
- Drainage Condition Known:
  - Drainage:
    - With GMF: 67%
    - No Drainage:
      - 3%: 84%
      - 16%: 86%

- Drainage Condition Unknown:
  - No Drainage:
    - 42%: 78%

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Average cost per earthwork failure

Drainage condition good
- £118k
Drainage condition poor
- £165k
Drainage condition unknown
- £166k

Watery defect
- £182k
No drainage
- £177k
Failure with gmf
- £235k

30% – 40% higher cost

Drainage condition good
- £147k
Drainage condition poor
- £177k
Drainage condition unknown
- £143k

No watery defect
- £166k
No drainage
- £209k

26/10/2017
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23
Average cost per earthwork failure

Drainage condition good

- £118k

Drainage condition poor

- £159k

Drainage condition unknown

- £165k

No Drainage

- £177k

Watery Defect

- £182k

No Watery Defect

- £235k

Failure with gmf

- £168k

20% – 40% higher cost
Conclusions

- Analysis showed 74% of the failures have some drainage related problem
  - Absent/insufficient drainage (6%)
  - Poor condition drainage (68%)