

Exploratory Data Analysis of the Northern Ireland Carriageway and Footway Surface Defects

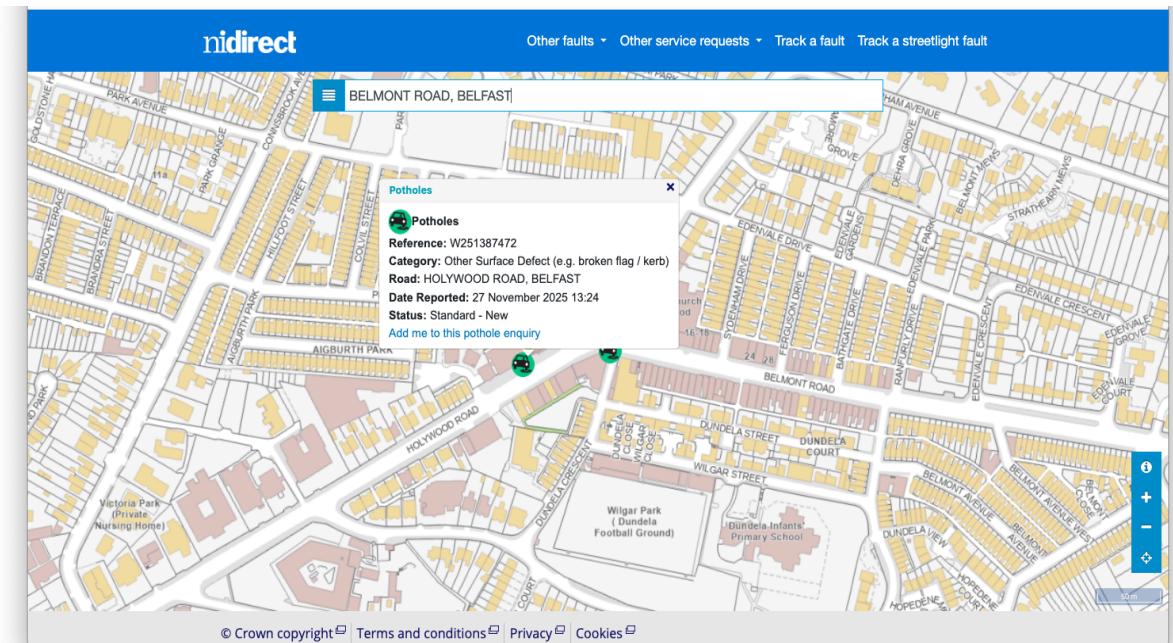
By Suzy Kell, Dec 2025

Background

The Northern Ireland Department for Infrastructure (DfI) receives information about defects to the public roads and pathways, some of which through a reporting system on the NI Direct website. Surface defects are recorded using a range of defect categories, e.g. pothole, rutted, depressed, cracked, uneven, etc., the defect location and road class. The four divisions (and section offices) prioritise repairs by severity and risk to the public, and offer a window of time for each project.

"For over a decade, the Department has faced a significant budget shortfall and has had to reduce its Essential Road maintenance activities to a Limited Service. This means that the Department is repairing only the highest priority defects along with the highest priority, safety related maintenance. Budget pressures continue and until such times as sufficient funding is made available, it will not be possible to change the current level of service, and the current iteration of limited-service model remains in place." - excerpt from the '*Northern Ireland Road Network and Condition Statistics 2024-25*' Report.

Fig. 1: Road defect reporting page on the [NI Direct website](#)



Business Task

Analyse the defect data for the 2025 time period to determine which carriageway issues are most prevalent, which areas are most affected and make recommendations for funding and resources to address these going forward.

Business Questions

1. Which road and path defects were most prevalent?
2. What time of year do most defects occur?
3. Which regional divisions/offices received the most reports?
4. How many defects were fixed on time, gone under or over time estimates?
5. Which kinds of defects usually go over initial time estimates?
6. Which divisions have performed the best and worst this year?
7. Which section offices have performed the best and worst this year?

Tools

Python for Data Cleaning, Data Transformation, Data Visualisation and Data Analysis

Data Set

Road and path defects reported from 1st April - 30th November 2025. The data set is publicly available on [OpenDataNI](#).

Who is Reading the Results of this Analysis?

- Division managers of the Northern Ireland Department for Infrastructure
- Journalists looking to report on the state of NI roadways and maintenance funding
- Concerned members of the Northern Ireland public

Glossary

See list of terms and explanations on page 22.

Appendix

See all data cleaning and exclusions on page 23.

Summary of Findings and Recommendations:

- There is a **large volume of road and path defects** reported to the Northern Ireland Department for Infrastructure on an ongoing basis - in the 8 months between April and November 2025, **69,243** issues were raised.
- The majority of defects were **bitmac and asphalt potholes on public roads (72%)**, largely occurring on **Unclassified (55%) and Class C (17%)**, lesser maintained roads highlighting the need for monitoring, preventative measures and investment in higher quality road materials.
- Overall, **75% of issues reported were successfully repaired** in this timeframe, with **77%** of these were completed **within the estimated timeframes** given.
- Completion rates should be improved considering that amongst the **25% that remained unaddressed**, communities have been left for **up to 200 days** with hazardous road conditions causing damage to private vehicles and making driving in these areas much more unsafe.
- Across the four regional divisions, the **Southern (30.7%) and Western (31%)** Divisions received the **largest volumes** of defect reports, especially for Unclassified and Class C roads.
- The **Southern Division** requires some investigation into staffing and efficiencies, as their **overall completion rate was only 67%**, with unfixed repairs remaining a hazard for on average 4 months (120 days).
- Within this division, **Armagh City, Banbridge and Craigavon East and West** both addressed **less than 50%** of reported defects, and projects running over on average 23 days compared to estimates (East section office).
- The Western Division similarly requires some oversight due to large volumes and apparent capacity issues. **Mid Ulster North** had **average completion times of 1 month (30 days)**, double that of any other office in this region, typically running over by 2 weeks compared to estimates.

Overall, there are clear performance issues given the volume of incoming road issues and the level of response capable by the section offices in each division. Funding is required to see that all major issues can be addressed in a timely manner, to avoid casualties and a massive private motor damage fund that remains necessary.

1. Which road and path defects are most prevalent?

- 69,243 road defects were reported between April-Nov 2025.
- 89.7% of these were carriageways (public roads), 10.3% were footways (paths) [Fig. 1]. 66.5% of these defects were on bitmac surfaces (less expensive), 30.8% asphalt (more hardwearing), and 2.7% concrete carriageways [Fig. 2] (see glossary for terms).

Fig. 2

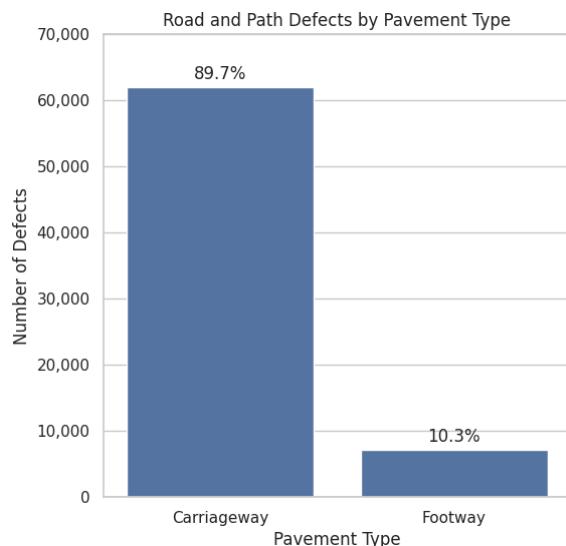
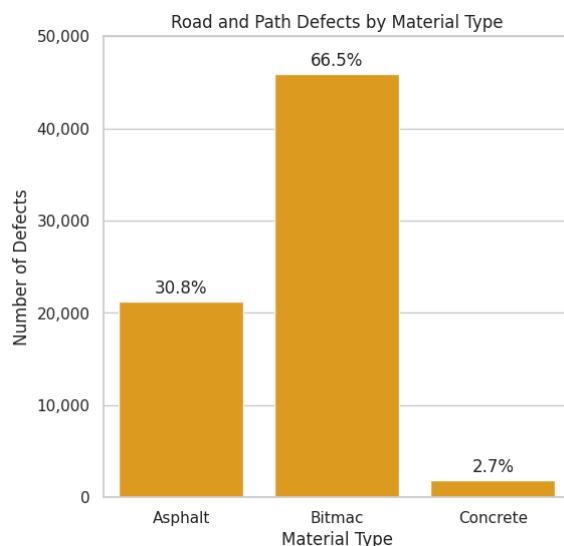
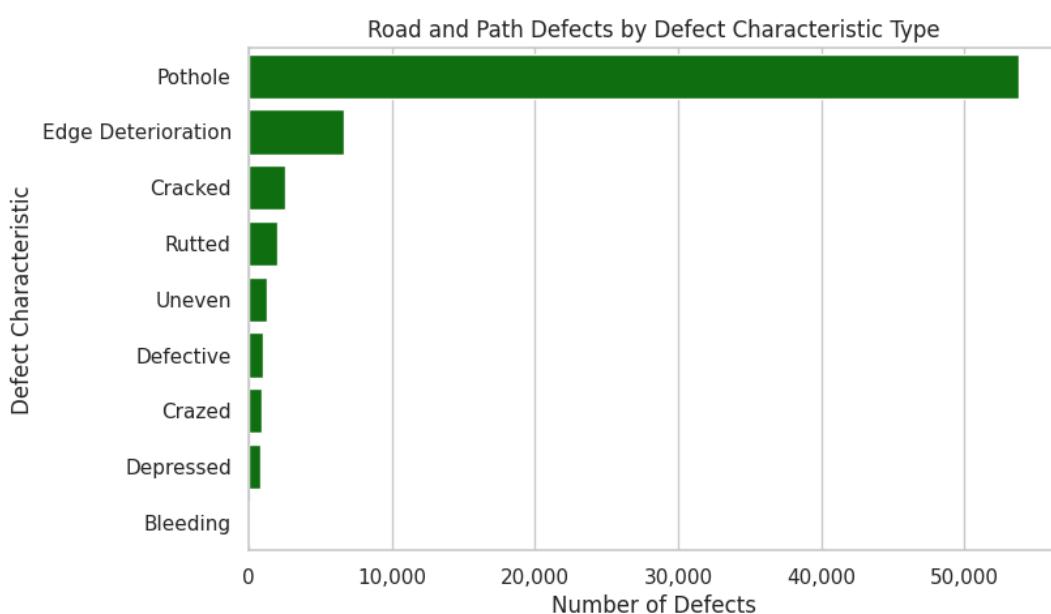


Fig. 3



- The most common defect types are as potholes (78%), followed by edge deterioration (9.6%), with all other defects occurring with much less frequency [Fig. 4].

Fig. 4



- Combining these defects, the most reported issues on the NI public roads and paths were as follows (grouping the bottom 15% of defects for ease of analysis) [Fig.5]:

Fig. 5

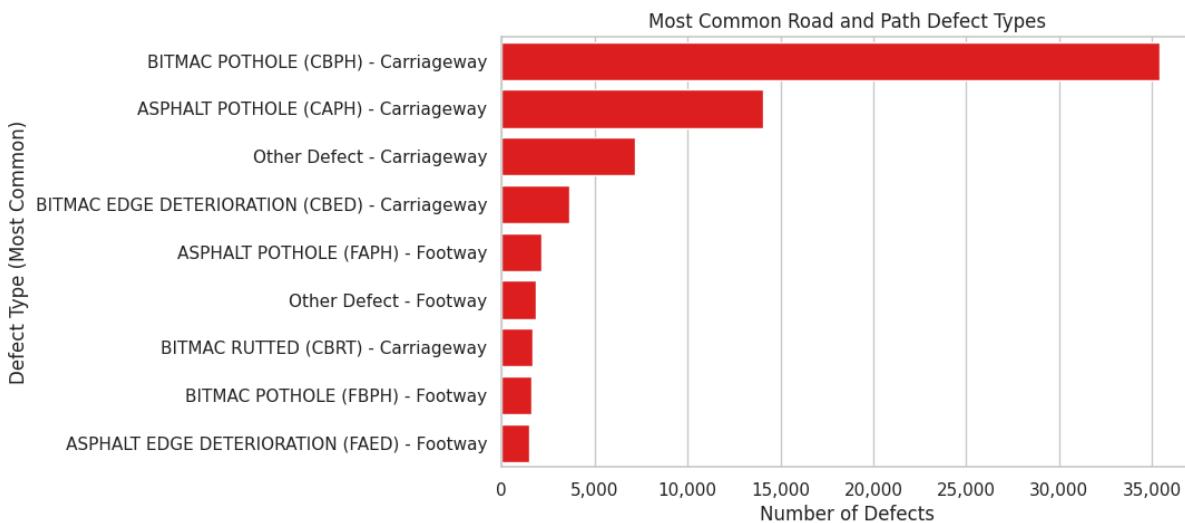


Table 1: Counts and percentage breakdown of the most common road defects

Most Common Defects	Count	%
BITMAC POTHOLE (CBPH) - Carriageway	35,393	51.3%
ASPHALT POTHOLE (CAPH) - Carriageway	14,043	20.3%
BITMAC EDGE DETERIORATION (CBED) - Carriageway	3,646	5.3%
ASPHALT POTHOLE (FAPH) - Footway	2,134	3.1%
BITMAC RUTTED (CBRT) - Carriageway	1,681	2.4%
BITMAC POTHOLE (FBPH) - Footway	1,626	2.4%
ASPHALT EDGE DETERIORATION (FAED) - Footway	1,466	2.1%
Other Defect - Carriageway	7,191	10.4%
Other Defect - Footway	1,871	2.7%

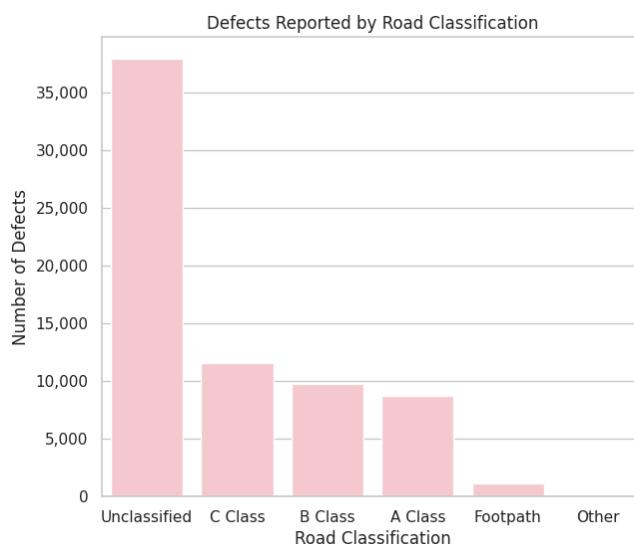
- As expected, carriageway bitmac potholes make up more than half of all defects [Table 1]. This may be due to the heavy wear and tear caused by constant use of roads (compared to footpaths) and the rate of degradation of bitmac as a road material.

- There was an interesting split of road defects by classification type, with over half of all defects occurring for unclassified, minor public roads. While these roads would get less daily use, it's clear they are less likely to be maintained or scouted for preventative work by section offices. This theory is supported by the declining percentage of defects as we scan from lower classes (class C) to higher (class A) [Table 2, Fig.6].

Table 2: Count and percentage breakdown of road classes with defects

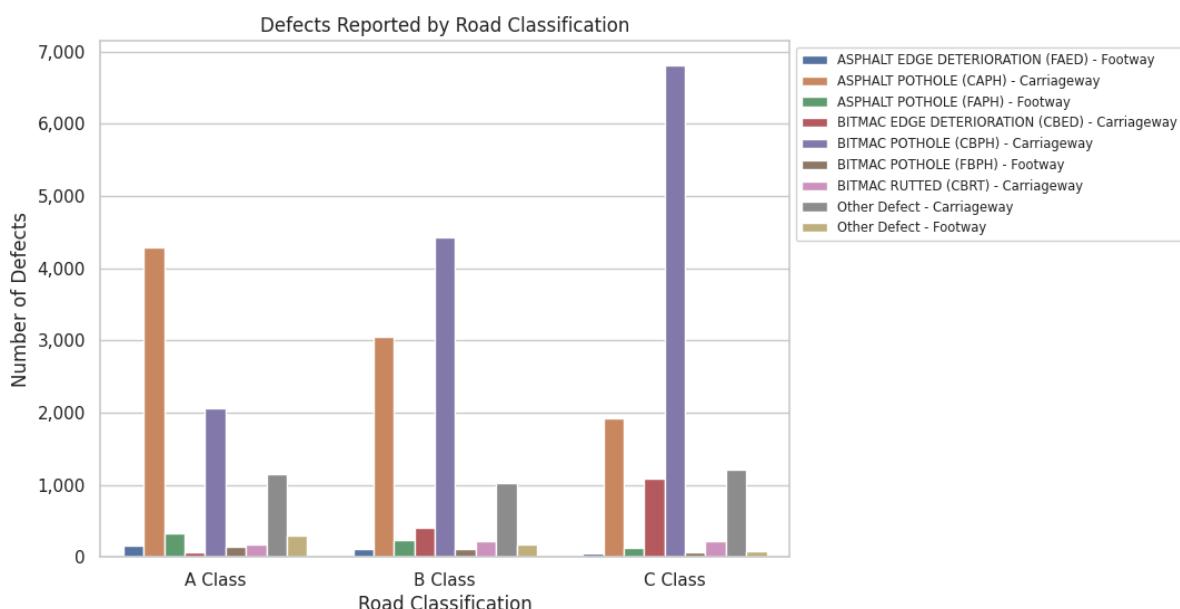
Road Class	Count	%
Unclassified	37,904	54.9%
C Class	11,579	16.8%
B Class	9,750	14.1%
A Class	8,689	12.6%
Footpath	1,099	1.6%
Other	30	0.0%

Fig. 6



- Looking at the breakdown of the most common defects [Fig. 7] amongst the three main road classes (A, B and C) there is a notable trend. Class A reports consist of mostly roads with asphalt potholes (orange columns), compared with Class B and C roads that are mostly bitmac potholes (purple columns) - once again signaling the quality of road materials by class (i.e. higher grade asphalt for Class A) and better maintenance on higher class roads (more heavily used).

Fig. 7



Insights and Comments:

Considering bitmac defects make up the majority of issues raised, and the fact that this is a less hardy and cheaper road material, it could be said that if budget allowed alternative materials should be trialed and used for future road development to ease the cost of repairs and payments for private car damage. (Note: the high percentage of issues may be due to the quality of materials, or due to the high proportion of roads made from this material - more context is required to make this inference).

Potholes on public roads make up a huge percentage of reported issues, meaning further analysis into the causes and prevention of this kind of defect would be very worthwhile. Currently a road scanning technology is being deployed by the DfI to gain a complete picture of the state of Northern Irish roads to continue this process.

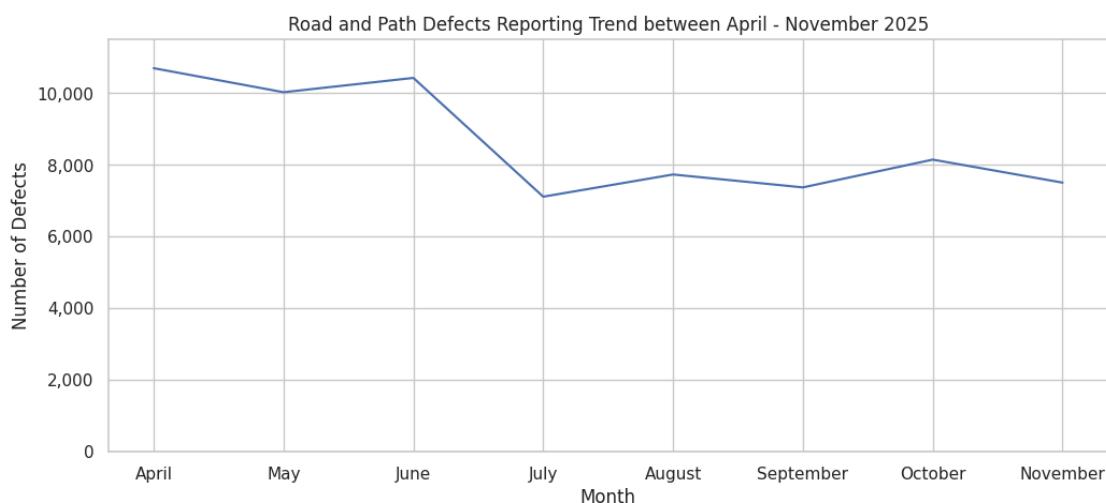
Section offices should prepare for the seasons ahead by negotiating deals on bitmac and asphalt repair supplies for pothole repairs especially and hiring contractors and repair staff with these repair skills in mind.

2. What time of year do most defects occur?

Monthly Reported Defects:

Analysis revealed that, while there was a step down in defects reported after June 2025, there do not seem to be any major seasonal trends i.e. a spike in cracks due to summer heat or harsh winter conditions [Fig. 8]. I will note that the data runs from April - November 2025 and a full year, if not multiple years of data, would be required to give a true sense of seasonality. Bottom line, the time of year does not seem to be a major driver in the volume of defects.

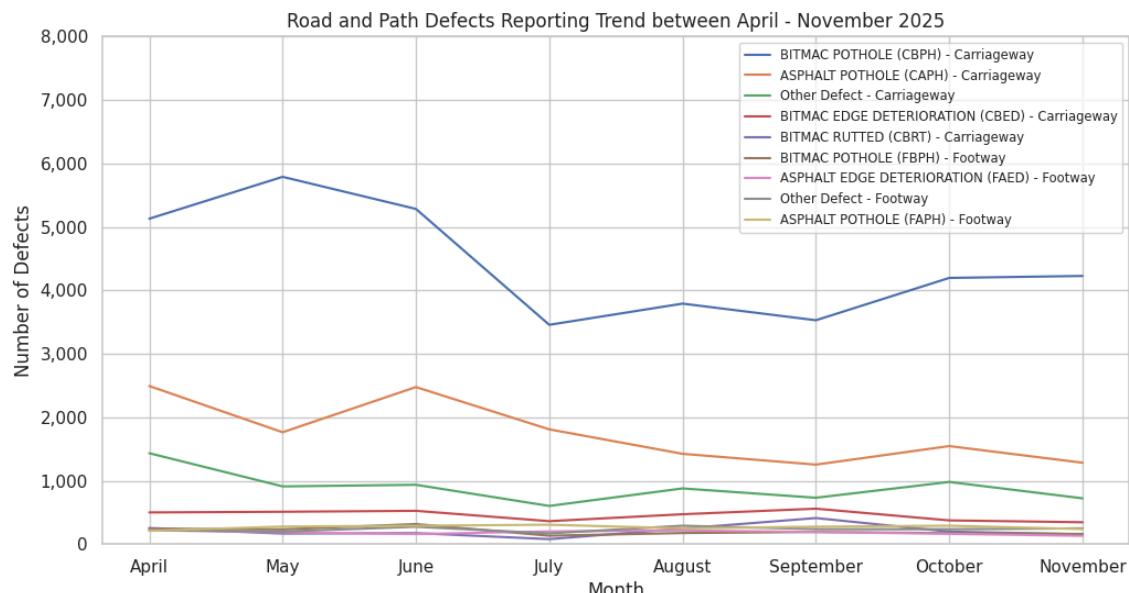
Fig. 8



Most common defects by Month:

The 7 most common defect types largely follow the same trend as the overall line chart, showing that no one defect type is driving this [Fig. 9]. One could say that carriageway bitmac defects began to increase in October and November with colder weather but more data would be required to confirm this.

Fig. 9



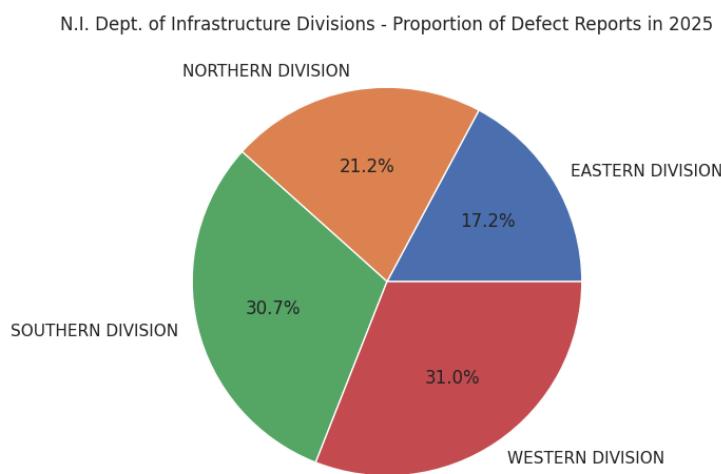
3. Which regional divisions/offices received the most reports?

There are four divisions that are responsible for road defect repairs in the north, south, east and west of Northern Ireland. Within these there are section offices that cover specific areas.

Volume of Defect Caseload by Division:

The Southern and Western divisions have the most reports of road and pathway issues, which is surprising considering the most populated areas in Belfast and the surrounding areas would be in the Eastern division [Fig. 10]. This suggests that road maintenance may be lacking resources in these divisions for monitoring and preventive works.

Fig. 10

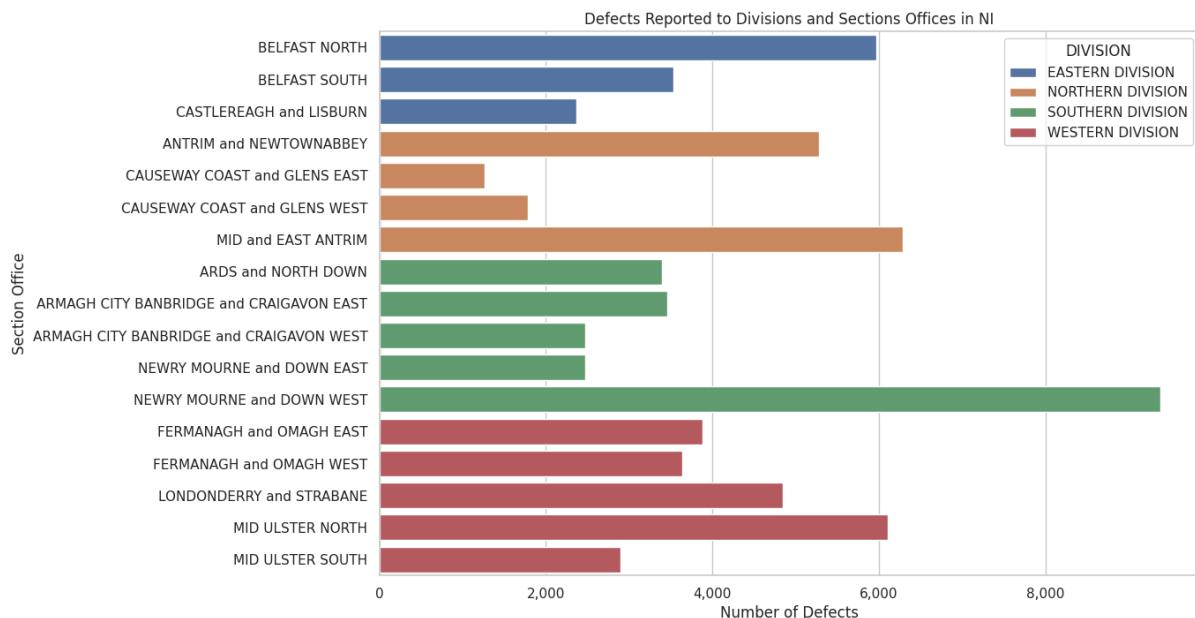


Volume of Defects across Section Offices:

While there are section offices in each division that account for large proportions of the defects reported [see next page. Fig. 11], 'Newry, Mourne and Down West' has a huge number of defects and makes up the bulk of reports coming from the Southern Division. Further analysis did not reveal any particular road that was the main source of these defect reports, nor a higher % of lower class roads reported compared to national and within its division (see division / class chart on next page), rather this office just had a large volume of defect reports to handle overall.

The Western Division had a similarly large number of defect reports, though much more evenly spread of reports across section offices in that region (see next page).

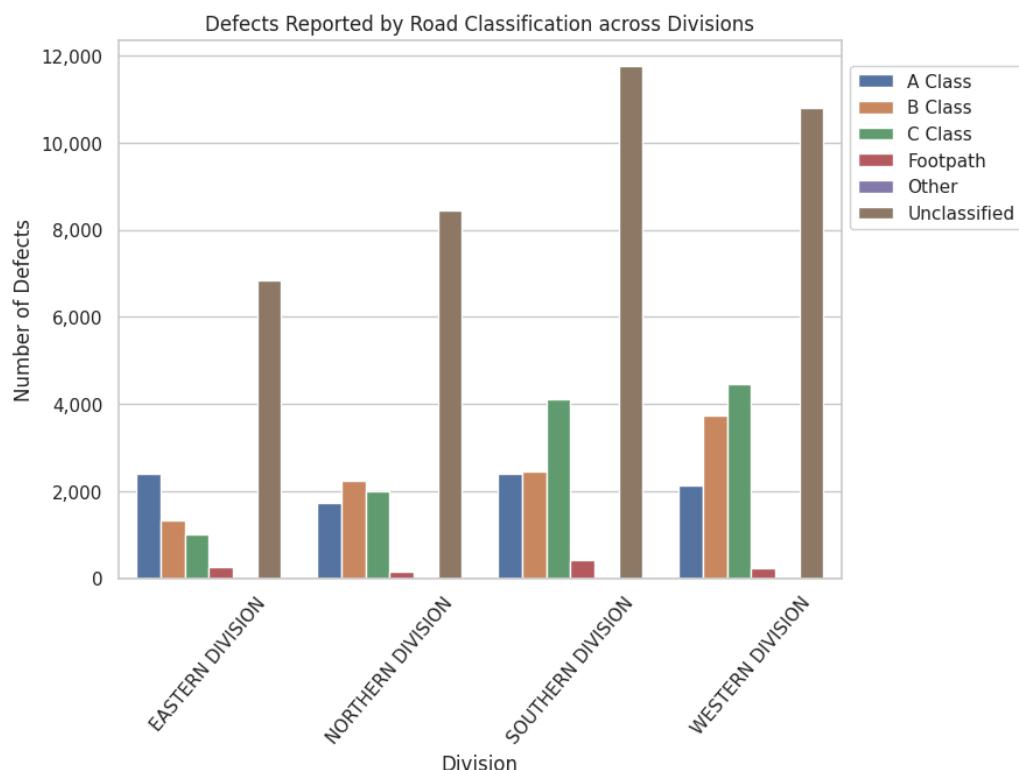
Fig. 11



Road Classifications across Regions - Number of Reports:

From the chart below it can be seen that the increase in volume of defect reports for the Southern and Western Divisions can be attributed to Class C (green) and Unclassified (brown) roads which appear to be much less well maintained or make up a greater proportion of the road networks in these divisions [Fig. 12].

Fig. 12

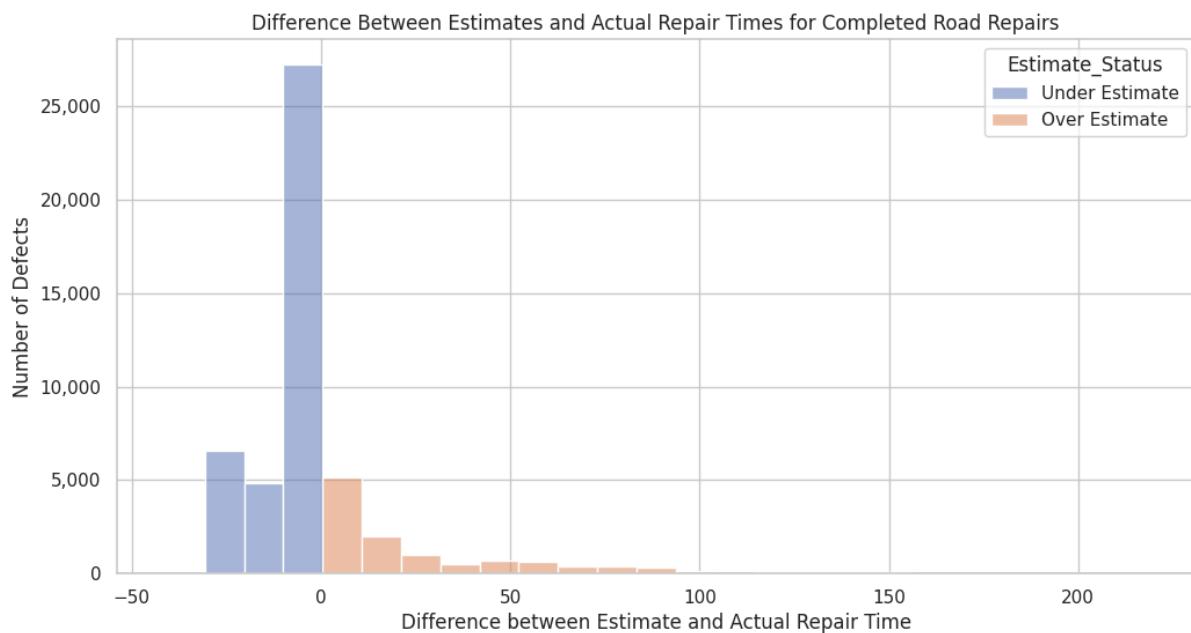


4. How many defects were fixed on time, gone under or over time estimates?

Completed Repairs:

- Overall, 75% of defects that were reported in this timeframe were successfully repaired by November 2025 [Fig.13].
- Each defect reported was assigned a repair time estimate, typically ranging from 1 day to 6 weeks.
 - The most common estimates given were 5 working days (54.1% of defects) or 4 weeks (38.4% of defects).
 - 76.9% of completed repairs were performed on-time or under-estimate, with 23.1% of repairs going over initial estimates.
 - In the chart below, the orange section shows that, while lower in volume, when repairs go over estimate they can run over by 50-100 days. This shows problematic levels of inaccuracy with regard to estimates and the extreme length of time potentially harmful road defects are left in the public sphere. Without a sense of the severity of these defects (this information may be obtained with more insight from the Dept of Infrastructure), it is unclear how much harm these cases represented. This should be raised for further investigation.

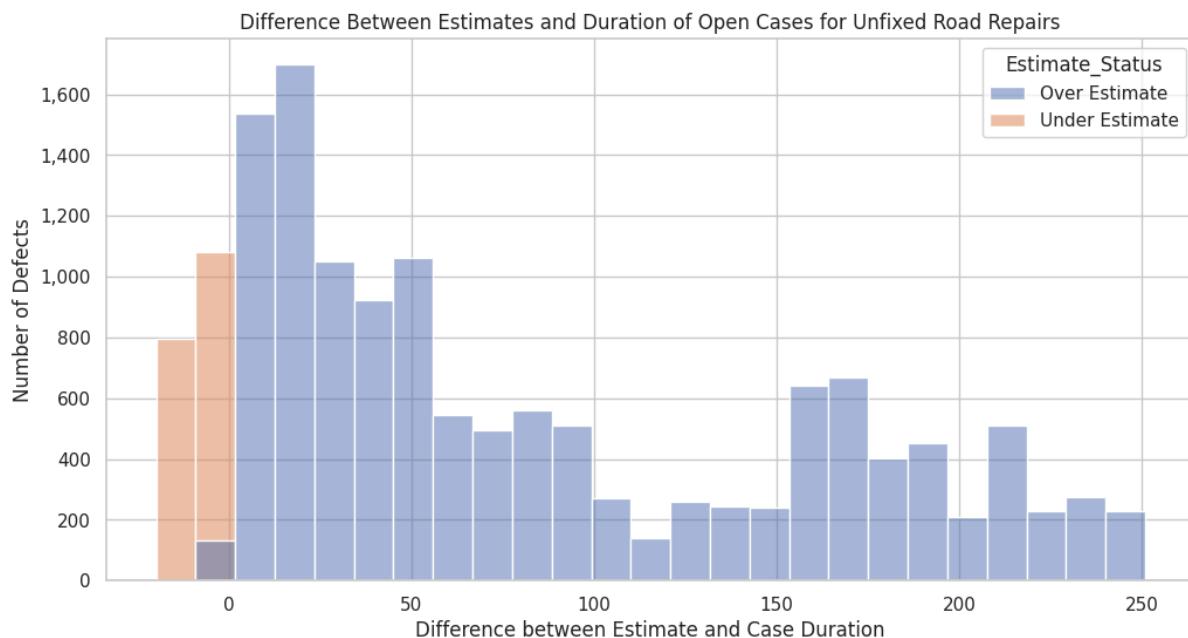
Fig. 13



Incomplete Repairs:

- 25% of defects that were reported in this timeframe were left without repairs [Fig. 14].
- The majority of unfixed issues have run over estimated times (in blue, Fig. 14) - with many running over by 50, 100 and up to 250 days. The number of these runovers is in the thousands and highlights some major issues in service delivery for some communities.
- Note: The orange section highlights issues in the system that were reported more recently and had not yet run over initial estimates by November 2025.

Fig. 14



Q5 Which kinds of defects usually go over initial time estimates?

Table 3: Completion statistics for repairs of the most common defects

Most Common Defects	Count	% of Defects	% of Successful Repairs	Average Time to Repair: Completed	Average Time in System: Incomplete
BITMAC POTHOLE (CBPH) - Carriageway	27,151	39.3%	76.7%	15.4 days	87.8 days
ASPHALT POTHOLE (CAPH) - Carriageway	11,036	16.0%	78.6%	12.3 days	104.6 days
Other Defect - Carriageway	4,777	6.9%	66.4%	15.3 days	126.2 days
BITMAC EDGE DETERIORATION (CBED) - Carriageway	2,551	3.7%	70.0%	13.3 days	98.6 days
ASPHALT POTHOLE (FAPH) - Footway	1,718	2.5%	80.5%	16.7 days	75.1 days
Other Defect - Footway	1,438	2.1%	76.9%	14.8 days	83.9 days
ASPHALT EDGE DETERIORATION (FAED) - Footway	1,264	1.8%	86.3%	23.5 days	62.1 days
BITMAC POTHOLE (FBPH) - Footway	1,067	1.5%	65.6%	14 days	138.2 days
BITMAC RUTTED (CBRT) - Carriageway	856	1.2%	50.9%	18.1 days	98.5 days

Q What are the completion rates for the most common road defect types?

- No one defect type appears to be driving the rate of completion of repairs (overall 75%).
- It can be seen that the most common defect types (Carriageway Bitmac Pothole: 39.3% and Carriageway Asphalt Potholes: 16%) have relatively high and similar completion rates (76-78%), with the lowest rates attributed to smaller groups of defects warranting less concern [Table 3].

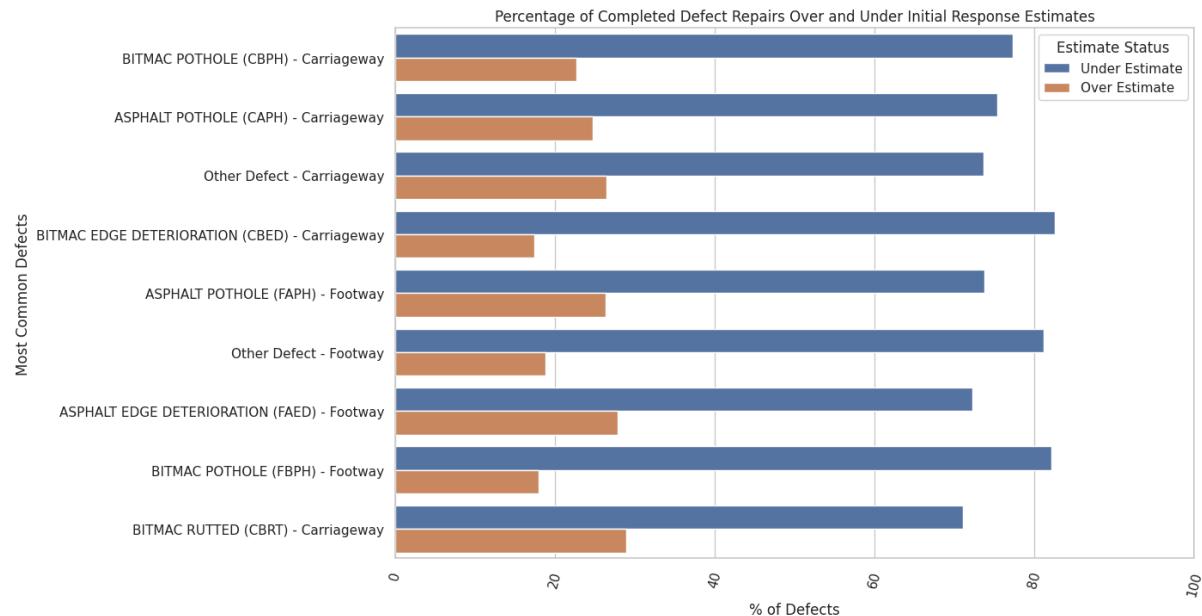
Q What is the average wait time in the system of each of the top defect types of defects?

- Table 3 shows that most defects take 2-3 weeks (12-23 days) to be repaired (Completed)
- However, the incomplete repairs (Incomplete) have been in the system an average of 2-4.5 months (62-138 days) awaiting repair. This is a long time for communities to be using potentially dangerous roads and paths.

Q For the most common defect types, what percentage of completed repairs come in over and under estimate times?

- Of the most common defects that were successfully repaired, between 17%-28% went over initial time estimates given by the section offices [Fig. 15].
- Of the top two most prevalent issues, Carriageway Bitmac Potholes went over time estimates for 22.7% of repairs and Carriageway Asphalt Potholes 24.7% of the time.

Fig. 15



Insights and Comments:

While there is no one defect type driving the delay in response times, the relevant departments should take care to make more accurate predictions and prepare staff and materials to address the most common issues to prevent such long waiting times for communities.

Q6 Which divisions have performed the best and worst this year?

Table 4: Completion statistics for repairs of the four regional divisions

Division	Count	% of Defects	% of Successful Repairs	Average Time to Repair: Completed	Average Time in System: Incomplete
Eastern Division	11,863	17%	86%	16 days	67 days
Northern Division	14,609	21%	73%	16 days	86 days
Southern Division	21,181	31%	67%	12 days	120 days
Western Division	21,375	31%	79%	16 days	92 days

Q What are the completion rates for defects reported to each division?

- Despite the large population serviced in the Eastern Division (including the city of Belfast), this division has the highest rate of repair completions at 86% [Table 4].
- The more concerning figure is the 67% success rate for the Southern Division, considering that it is responsible for almost a third of all defects reported. This division may be struggling with funding and resources to address the volume of repairs required.

Q What is the average wait time in the system for each division?

- Table 4 shows that most defects (Completed) take an average of just over 2 weeks to repair (16 days), with the Southern Division taking much less time on average (11.9 days) to address the issues they can get to.
- However, the incomplete repairs (Incomplete) have a wide range of wait times in the system, with the Southern (119.7 days) and Western (91.9 days) Divisions having the longest times, reflecting the larger proportion of repairs they have been assigned to fix.

Q Across divisions, what percentage of completed repairs come in over and under estimate times?

- Interestingly, the Eastern and Northern Divisions have more inaccurate estimate times (1.6-4.6 days over) as a higher percentage of repairs went over those given initially- 26.7% (Eastern) and 29.1% (Northern) [Fig. 16].
- While Southern and Western Divisions have larger proportions of repairs, and longer delays for incomplete repairs, their estimations for repairs that did get fixed were slightly more accurate - 20.3% repairs running over for both of these divisions [Table 5]. These were typically 1.7 to 2.4 days under estimate.

Fig. 16

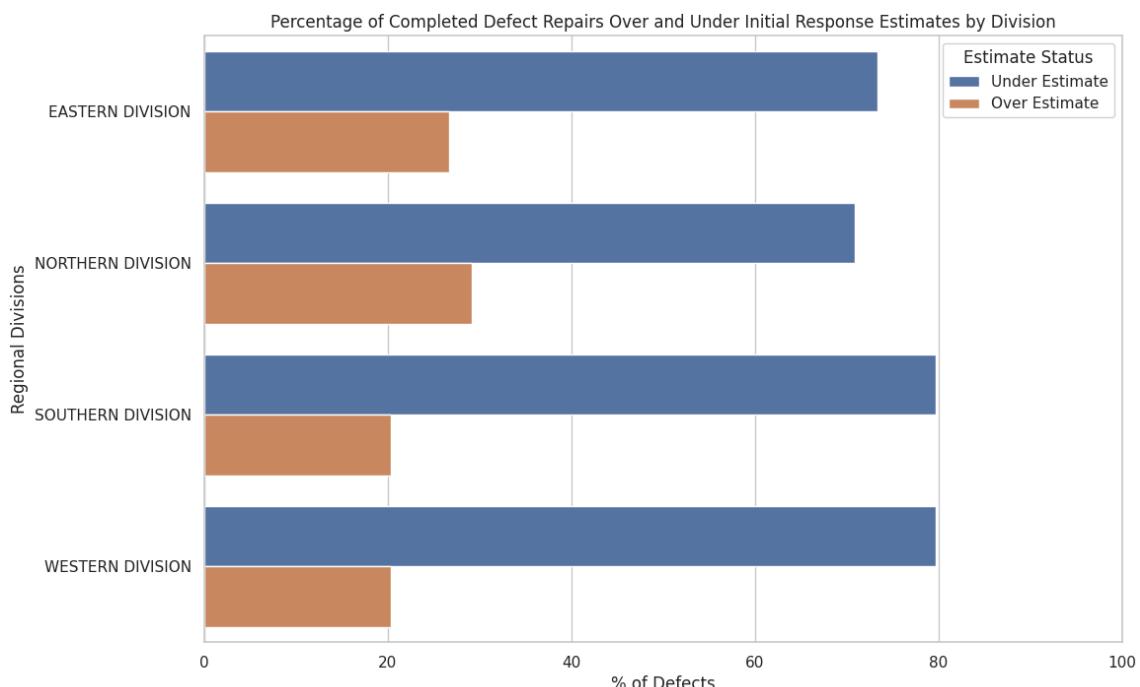


Table 5: Average time difference from initial estimates for defect repairs across divisions

Division	% of Defects	Average Difference from Time Estimate
Eastern Division	17%	4.6 days over
Northern Division	21%	1.6 days over
Southern Division	31%	-2.4 days under
Western Division	31%	-1.7 days under

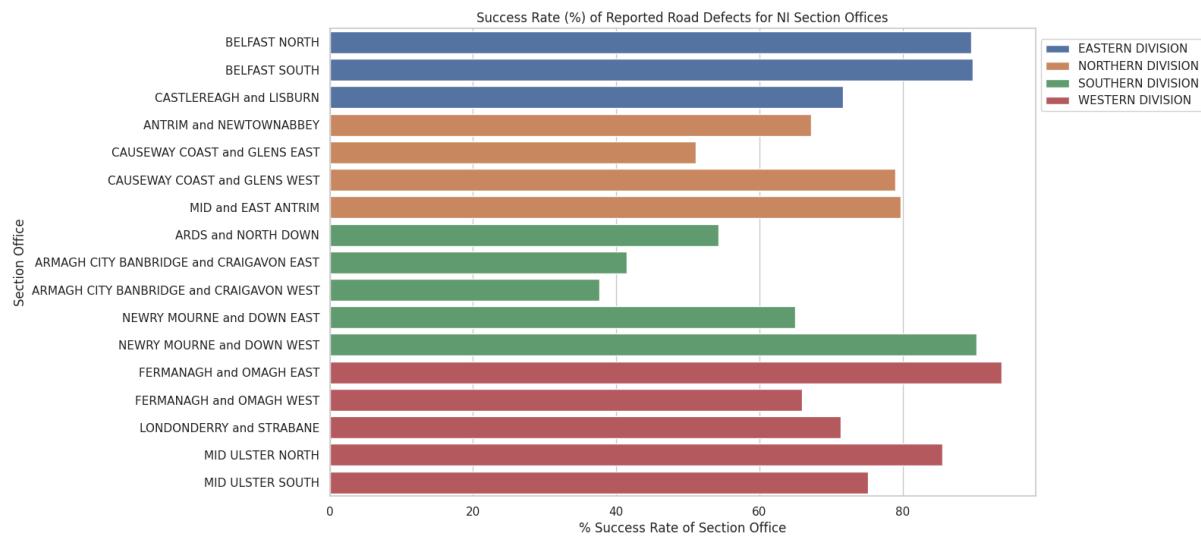
Q6 Which section offices have performed the best and worst this year?

Table 6: Completion statistics for repairs of the section offices

Section Office	Count	% of Total Defects	% of Successful Repairs	Average Time to Repair: Completed	Average Time in System: Incomplete
Eastern Division					
Belfast North	5,963	8.6%	90%	20 days	55 days
Belfast South	3,530	5.1%	90%	11 days	63 days
Castlereagh and Lisburn	2,370	3.4%	72%	13 days	81 days
Northern Division					
Antim and Newtonabbey	5,277	7.6%	67%	13 days	85 days
Causeway Coast and Glens East	1,263	1.8%	51%	9 days	127 days
Causeway Coast and Glens West	1,781	2.6%	79%	9 days	99 days
Mid and East Antrim	6,288	9.1%	80%	22 days	63 days
Southern Division					
Ards and North Down	3,397	4.9%	54%	21 days	82 days
Armagh City, Banbridge and Craigavon East	3,461	5.0%	42%	33 days	156 days
Armagh City, Banbridge and Craigavon West	2,476	3.6%	38%	21 days	121 days
Newry, Mourne and Down East	2,468	3.6%	65%	9 days	136 days
Newry, Mourne and Down West	9,379	13.6%	90%	6 days	86 days
Western Division					
Fermanagh and Omagh East	3,885	5.6%	94%	10 days	72 days
Fermanagh and Omagh West	3,642	5.3%	66%	14 days	92 days
Londonderry and Strabane	4,847	7.0%	71%	7 days	103 days
Mid Ulster North	6,101	8.8%	86%	30 days	91 days
Mid Ulster South	2,900	4.2%	75%	11 days	78 days

Q What are the completion rates for defects reported to each office?

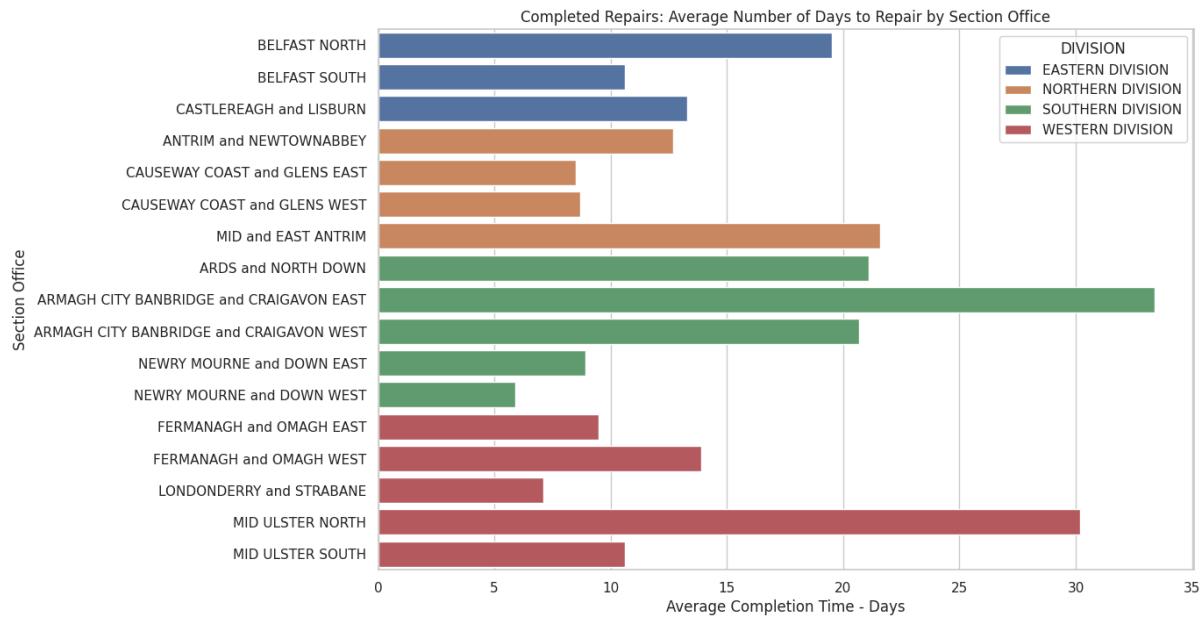
Fig. 17



- The Southern Division is having the most performance issues of any division, with Armagh City, Banbridge and Craigavon East (42%) and West (38%) [green] both successfully completing less than 50% of reported defects [Table 6, Fig. 17].
- These section offices, in addition to Causeway Coast and Glens East (51%, orange) should be contacted to investigate funding and capacity issues.
- Despite Newry, Mourne and Down West (also Southern) having a large proportion of defects, the success rate of this office has been 90%.

Q What is the average wait time in the system for each office?

Fig. 18



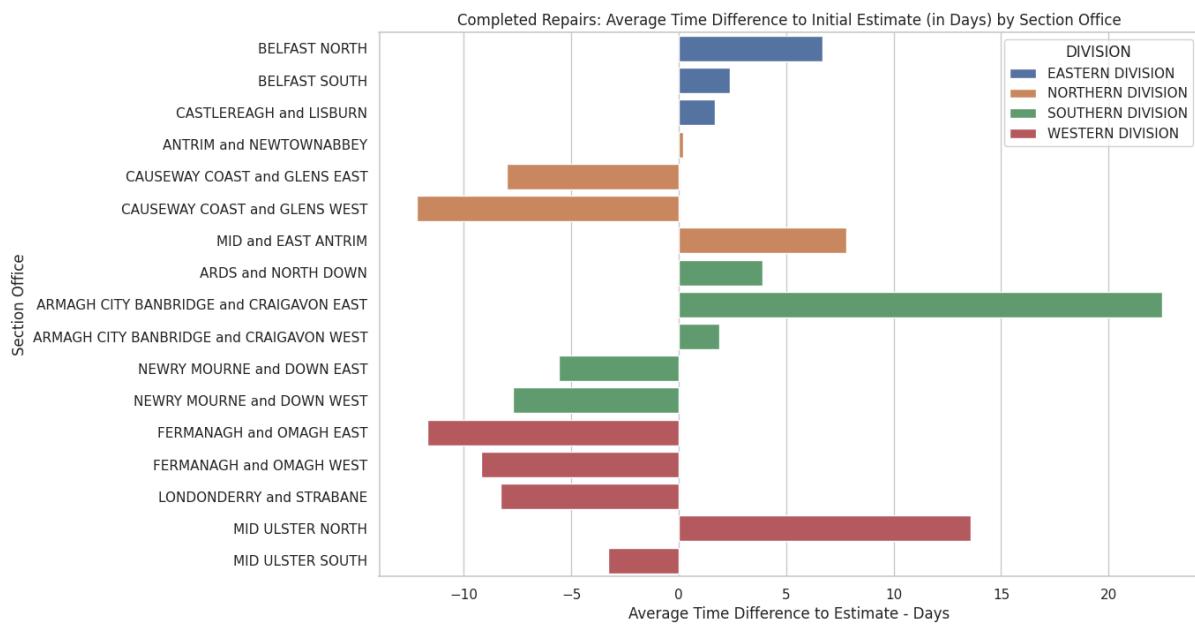
- Problems in Armagh City, Banbridge and Craigavon East (Southern Division, green) are even more apparent seeing that successful repairs take a month on average (33 days) to complete, with incomplete repairs staying unfixed for an average of 5 months (156 days) [Fig. 18]. These figures are quite concerning and should be looked into locally.
- The burden of large volumes of repairs seems to affect Mid Ulster North (Western Division, red) with successful repairs also taking an average of 1 month (30 days) to address, which is more than double the response times in any other section office in that region. This too should be looked into for potential funding and staffing issues.

Q Across offices, what percentage of completed repairs come in over and under estimate times?

Table 7: Average time difference from initial estimates for defect repairs across section offices

Section Office	% of Total Defects	Difference to Time Estimate
Eastern Division		
Belfast North	8.6%	7 days
Belfast South	5.1%	2 days
Castlereagh and Lisburn	3.4%	2 days
Northern Division		
Antim and Newtonabbey	7.6%	0 days
Causeway Coast and Glens East	1.8%	-8 days
Causeway Coast and Glens West	2.6%	-12 days
Mid and East Antrim	9.1%	8 days
Southern Division		
Ards and North Down	4.9%	4 days
Armagh City, Banbridge and Craigavon East	5.0%	23 days
Armagh City, Banbridge and Craigavon West	3.6%	2 days
Newry, Mourne and Down East	3.6%	-6 days
Newry, Mourne and Down West	13.6%	-8 days
Western Division		
Fermanagh and Omagh East	5.6%	-12 days
Fermanagh and Omagh West	5.3%	-9 days
Londonderry and Strabane	7.0%	-8 days
Mid Ulster North	8.8%	14 days
Mid Ulster South	4.2%	-3 days

Fig. 19



- It can be seen that there is a split amongst section offices, with many average repair times coming under initial estimates (most of the Northern and Western Divisions), whilst others go over estimates (all of the Eastern, most of the Southern Divisions) [Table 7, Fig. 19].
- As noted already, the Armagh City, Banbridge and Craigavon East (Southern Division, green) has quite a large average run over time (23 days over estimate) as well as Mid Ulster North (Western Division, red) at 14 days over estimates. Given this context, these two section offices should be contacted to see what resources or efficiencies are lacking preventing them from providing a better service to their local communities.

Glossary

Carriageway: This is a public road or motorway

Footway: This is a public footpath

Road Defect: This is an issue or fault in a road or path. This can be a pothole, crack, depression or other source of danger to the public and private motor vehicles.

DfI: Northern Ireland Department for Infrastructure

Bitmac: This is a more modern version of tarmacadam, which replaces the tar component with bitumen. Bitmac is primarily used as a basecoat or base layer for road surfacing. It is not as hard-wearing as the more expensive Asphalt, lasting approximately 10-15 years. Usually black in colour, bitmac is identifiable as having a coarse look of tightly packed stones or aggregate vs. Asphalt's smoother finish. ([Source](#))

Asphalt: This more hard-wearing than bitmac. It can typically last 25-30 years. Due to its durable nature, Asphalt is normally applied as the top layer of surfacing in applications such as roads, motorways and other commercial and residential surfaces. It is a combination of binder, aggregates and filler. Similar to Bitmac, bitumen is commonly used as the binder in Asphalt, however, it uses finer aggregates resulting in a smoother surface. ([Source](#))

Road Class: As provided by the NI Department for Infrastructure ([Source](#))

Motorway - A normally dual carriageway road designed for higher speed traffic with designated places for joining and leaving.

A roads - major roads intended to provide large-scale transport links within or between areas.

B roads - roads intended to connect different areas, and to feed traffic between A roads and smaller roads on the network.

C roads - smaller roads intended to connect together unclassified roads with A and B roads. **Unclassified roads** - local roads intended for local traffic.

Appendix I - Data Cleaning

See Python script (Jupyter Notebook [LINK](#)) for full details.

1. **Missing Data:** I checked for any concerning null values in the data and did not find any. I addressed the date format for (correctly) absent data that was in the form "01/01/9999 00:00:00" (see below).
2. **Incorrect Data Types:** The RECORDED_DATE and ACTUAL_COMPLETION_DATE were reading as categorical data (object) and these should be date variables. I converted both to dates and checked the date range of the defects (row items) and assessed whether the 'actual completion date' was useful and fit for purpose.
3. **Duplicate Data:** I checked for any duplicates, as it was likely that two members of the public reported the same defect without realising. I checked for duplicate records by Instruction Number (repair IDs) and removed a small number of obvious duplicated rows.

I further checked for duplicates by Instruction Number, Easting and Northing to check for duplicates of defects in the same location. After sampling some of the approx 700 'duplicates', it was not possible to determine if these were the same road defects or reoccurring, I decided not to remove them. They only accounted for 0.9% of the data and were unlikely to cause any bias in the data.

4. **Archived Reports:** A portion of the data was classified as 'Archived'. After investigating, the vast majority of cases were closed in just a few hours suggesting this data was either duplicated or invalid. Archived cases were removed from this analysis.
5. **Unknown Data Labels:** The DfI provided a key for the data (see Appendix II), but some pavement types were still unclear (L and D) so were labelled as Unknown Type. To simplify analysis, 'Hardshoulder' and 'Unknown Type' roads were removed from the analysis but only accounted for approx 200 cases, having almost no effect on the outcomes.
6. **Time Frame:** To prevent any confusion in trended graphs (i.e dips in performance for December 2025), only data from 1st April - 30th November 2025 was used for this analysis. Further analysis could examine seasonal trends over the previous years for a more complete picture, however this is out of scope for this project.