ERG3010 Project

US Bridges

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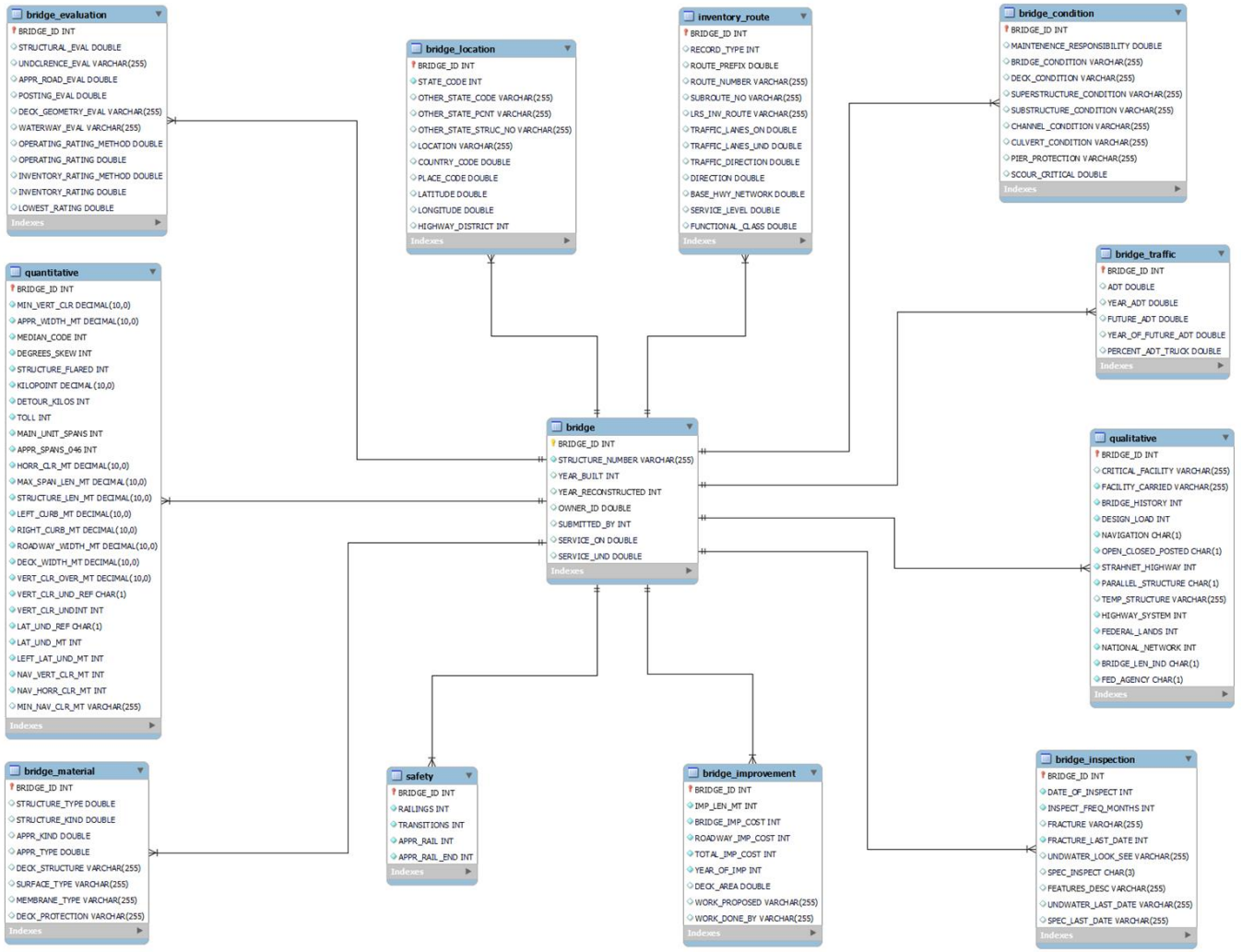
Introduction

- Proper assessment of bridge conditions are **essential** to providing a safe transportation system
- The ability to use data enables an **efficient** and **effective** way to manage bridge inventories
- The application of data-driven methods is vital to **improve the performance management** of the nation's highway bridges

Specification Continued

Code	Description	Code	Description	Code	Description
1	Alabama	22	Louisiana	40	Oklahoma
2	Alaska	23	Maine	41	Oregon
4	Arizona	24	Maryland	42	Pennsylvania
5	Arkansas	25	Massachusetts	44	Rhode Island
6	California	26	Michigan	45	South Carolina
8	Colorado	27	Minnesota	46	South Dakota
9	Connecticut	28	Mississippi	47	Tennessee
10	Delaware	29	Missouri	48	Texas
11	District of Columbia	30	Montana	49	Utah
12	Florida	31	Nebraska	50	Vermont
13	Georgia	32	Nevada	51	Virginia
15	Hawaii	33	New Hampshire	53	Washington
16	Idaho	34	New Jersey	54	West Virginia
17	Illinois	35	New Mexico	55	Wisconsin
18	Indiana	36	New York	56	Wyoming
19	Iowa	37	North Carolina	72	Puerto Rico
20	Kansas	38	North Dakota		
21	Kentucky	39	Ohio		

ER Diagram


bridge_evaluation
BRIDGE_ID INT
STRUCTURAL_EVAL DOUBLE
UNDCLRENCE_EVAL VARCHAR(255)
APPR_ROAD_EVAL DOUBLE
POSTING_EVAL DOUBLE
DECK_GEOMETRY_EVAL VARCHAR(255)
WATERWAY_EVAL VARCHAR(255)
OPERATING_RATING_METHOD DOUBLE
OPERATING_RATING DOUBLE
INVENTORY_RATING_METHOD DOUBLE
INVENTORY_RATING DOUBLE
LOWEST_RATING DOUBLE
Indexes
bridge_location
BRIDGE_ID INT
STATE_CODE INT
OTHER_STATE_CODE VARCHAR(255)
OTHER_STATE_PCNT VARCHAR(255)
OTHER_STATE_STRUC_NO VARCHAR(255)
LOCATION VARCHAR(255)
COUNTRY_CODE DOUBLE
PLACE_CODE DOUBLE
LATITUDE DOUBLE
LONGITUDE DOUBLE
HIGHWAY_DISTRICT INT
Indexes
inventory_route
BRIDGE_ID INT
RECORD_TYPE INT
ROUTE_PREFIX DOUBLE
ROUTE_NUMBER VARCHAR(255)
SUBROUTE_NO VARCHAR(255)
LRS_INV_ROUTE VARCHAR(255)
TRAFFIC_LANES_ON DOUBLE
TRAFFIC_LANES_UND DOUBLE
TRAFFIC_DIRECTION DOUBLE
DIRECTION DOUBLE
BASE_HWY_NETWORK DOUBLE
SERVICE_LEVEL DOUBLE
FUNCTIONAL_CLASS DOUBLE
Indexes
bridge_condition
BRIDGE_ID INT
MAINTENENCE_RESPONSIBILITY DOUBLE
BRIDGE_CONDITION VARCHAR(255)
DECK_CONDITION VARCHAR(255)
SUPERSTRUCTURE_CONDITION VARCHAR(255)
SUBSTRUCTURE_CONDITION VARCHAR(255)
CHANNEL_CONDITION VARCHAR(255)
CULVERT_CONDITION VARCHAR(255)
PIER_PROTECTION VARCHAR(255)
SCOUR_CRITICAL DOUBLE
Indexes
quantitative
BRIDGE_ID INT
MIN_VERT_CLR DECIMAL(10,0)
APPR_WIDTH_MT DECIMAL(10,0)
MEDIAN_CODE INT
DEGREES_SKEW INT
STRUCTURE_FLARED INT
KILOPOINT DECIMAL(10,0)
DETOUR_KILOS INT
TOLL INT
MAIN_UNIT_SPANS INT
APPR_SPANS_046 INT
HORR_CLR_MT DECIMAL(10,0)
MAX_SPAN_LEN_MT DECIMAL(10,0)
STRUCTURE_LEN_MT DECIMAL(10,0)
LEFT_CURB_MT DECIMAL(10,0)
RIGHT_CURB_MT DECIMAL(10,0)
ROADWAY_WIDTH_MT DECIMAL(10,0)
DECK_WIDTH_MT DECIMAL(10,0)
VERT_CLR_OVER_MT DECIMAL(10,0)
VERT_CLR_UND_REF CHAR(1)
VERT_CLR_UNDINT INT
LAT_UND_REF CHAR(1)
LAT_UND_MT INT
LEFT_LAT_UND_MT INT
NAV_VERT_CLR_MT INT
NAV_HORR_CLR_MT INT
MIN_NAV_CLR_MT VARCHAR(255)
Indexes
bridge_traffic
BRIDGE_ID INT
ADT DOUBLE
YEAR_ADT DOUBLE
FUTURE_ADT DOUBLE
YEAR_OF_FUTURE_ADT DOUBLE
PERCENT_ADT_TRUCK DOUBLE
Indexes
bridge
BRIDGE_ID INT
STRUCTURE_NUMBER VARCHAR(255)
YEAR_BUILT INT
YEAR_RECONSTRUCTED INT
OWNER_ID DOUBLE
SUBMITTED_BY INT
SERVICE_ON DOUBLE
SERVICE_UND DOUBLE
Indexes
qualitative
BRIDGE_ID INT
CRITICAL_FACILITY VARCHAR(255)
FACILITY_CARRIED VARCHAR(255)
BRIDGE_HISTORY INT
DESIGN_LOAD INT
NAVIGATION CHAR(1)
OPEN_CLOSED_POSTED CHAR(1)
STRAHNET_HIGHWAY INT
PARALLEL_STRUCTURE CHAR(1)
TEMP_STRUCTURE VARCHAR(255)
HIGHWAY_SYSTEM INT
FEDERAL_LANDS INT
NATIONAL_NETWORK INT
BRIDGE_LEN_IND CHAR(1)
FED_AGENCY CHAR(1)
Indexes
bridge_material
BRIDGE_ID INT
STRUCTURE_TYPE DOUBLE
STRUCTURE_KIND DOUBLE
APPR_KIND DOUBLE
APPR_TYPE DOUBLE
DECK_STRUCTURE VARCHAR(255)
SURFACE_TYPE VARCHAR(255)
MEMBRANE_TYPE VARCHAR(255)
DECK_PROTECTION VARCHAR(255)
Indexes
safety
BRIDGE_ID INT
RAILINGS INT
TRANSITIONS INT
APPR_RAIL INT
APPR_RAIL_END INT
Indexes
bridge_improvement
BRIDGE_ID INT
IMP_LEN_MT INT
BRIDGE_IMP_COST INT
ROADWAY_IMP_COST INT
TOTAL_IMP_COST INT
YEAR_OF_IMP INT
DECK_AREA DOUBLE
WORK_PROPOSED VARCHAR(255)
WORK_DONE_BY VARCHAR(255)
Indexes
bridge_inspection
BRIDGE_ID INT
DATE_OF_INSPECT INT
INSPECT_FREQ_MONTHS INT
FRACTURE VARCHAR(255)
FRACTURE_LAST_DATE INT
UNDWATER_LOOK_SEE VARCHAR(255)
SPEC_INSPECT CHAR(3)
FEATURES_DESC VARCHAR(255)
UNDWATER_LAST_DATE VARCHAR(255)
SPEC_LAST_DATE VARCHAR(255)
Indexes

What is the unique number of each bridge?

Query:

```
SELECT DISTINCT COUNT(BRIDGE_ID) AS UNIQUE_NUM_BRIDGE FROM BRIDGE
GROUP BY STRUCTURE_NUMBER;
```

Output:

UNIQUE_NUM_BRIDGE
1
2
3
4
5
6
7
8
9

- We obtain the unique number of each bridge by selecting distinct BRIDGE_ID fields from the table BRIDGE
- COUNT is used to obtain the index
- The results are grouped by STRUCTURE_NUMBER to ensure each UNIQUE_NUM_BRIDGE index corresponds to each distinct STRUCTURE_NUMBER

How many bridges have been built in the US?

Query:

```
SELECT DISTINCT COUNT(BRIDGE_ID) AS NUM_BRIDGE_US FROM BRIDGE;
```

Output:

NUM_BRIDGE_US
629153

- Similar to the previous question, distinct BRIDGE_ID fields are selected
- COUNT is used to calculate the total number of bridges

In what year did the US build the largest number of bridges?

Query:

```
SELECT YEAR_BUILT, COUNT(BRIDGE_ID) as NUM_BRIDGE
FROM bridge
GROUP BY YEAR_BUILT
ORDER BY COUNT(BRIDGE_ID) DESC
LIMIT 1;
```

- Columns YEAR_BUILT and BRIDGE_ID are selected from the table BRIDGE
- COUNT is applied to BRIDGE_ID and results are grouped by YEAR_BUILT to obtain the total number of bridges per year

Output:

YEAR_BUILT	NUM_BRIDGE
1960	13011

- Values for the total number of bridges per year is stored in NUM_BRIDGE
- They are then arranged in a decreasing order
- LIMIT 1 is used to obtain the highest value in NUM_BRIDGE
- The corresponding year is 1960

Which state in the US build the largest number of bridges?

Query:

```
SELECT STATE_CODE, COUNT(BRIDGE_ID) as NUM_BRIDGE
FROM bridge_location
GROUP BY STATE_CODE
ORDER BY COUNT(BRIDGE_ID) DESC
LIMIT 1;
```

- Columns STATE_CODE and BRIDGE_ID are selected from the table BRIDGE_LOCATION
- COUNT is applied to BRIDGE_ID and results are grouped by STATE_CODE to obtain total number of bridges for each state

Output:

STATE_CODE	NUM_BRIDGE
48	54697

- Values of the total number of bridges for each state are ordered in a decreasing manner
- LIMIT 1 is used to obtain the largest NUM_BRIDGE value
- The corresponding state is state number 28 (Texas)

Which two states in the US have the most interstate bridges?

Query:

```
SELECT bridge_location.STATE_CODE, count(*) as NUM_INTERSTATE_BRIDGE
FROM bridge_location
INNER JOIN inventory_route ON bridge_location.BRIDGE_ID=inventory_route.BRIDGE_ID
GROUP BY STATE_CODE, ROUTE_PREFIX
HAVING ROUTE_PREFIX = 1
ORDER BY count(*) DESC
LIMIT 2;
```

Output:

STATE_CODE	NUM_INTERSTATE_BRIDGE
48	6657
6	4010

After Optimization:

```
SELECT STATE_CODE, COUNT(BRIDGE_ID) AS NUM_INTERSTATE_BRIDGE FROM BRIDGE_LOCATION
WHERE BRIDGE_ID IN (SELECT BRIDGE_ID FROM INVENTORY_ROUTE WHERE ROUTE_PREFIX = 1)
GROUP BY STATE_CODE
ORDER BY NUM_INTERSTATE_BRIDGE DESC
LIMIT 2;
```

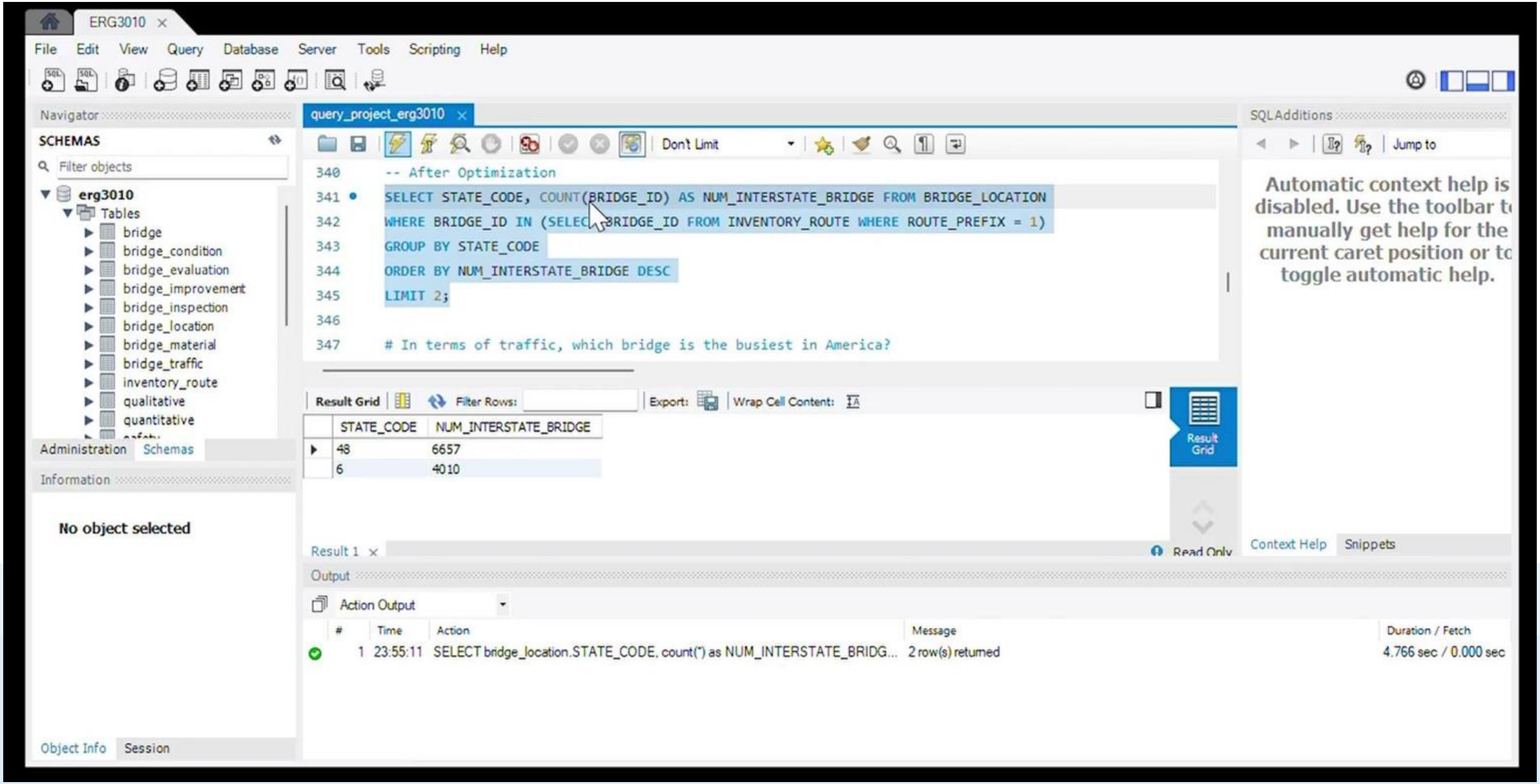
❖ *Before Optimization*

- **Column STATE_CODE is selected from table BRIDGE_LOCATION**
- **INNER JOIN is applied to select records with matching BRIDGE_ID in tables BRIDGE_LOCATION and INVENTORY_ROUTE**
- **COUNT and GROUP BY is applied to obtain the total number of interstate bridges (where ROUTE_PREFIX is 1) for each state**
- **Values are then arranged in a descending order**
- **The two largest values are chosen**
- **The corresponding states are California and Texas**

❖ *After Optimization*

- **INNER JOIN is replaced by WHERE and IN**

Optimization Video



In terms of traffic, which bridge is the busiest in the US?

Query:

```
SELECT BRIDGE_ID, ADT
FROM bridge_traffic
ORDER BY ADT DESC
LIMIT 1;
```

Output:

BRIDGE_ID	ADT
250005	919000

- Columns BRIDGE_ID and ADT are selected from table BRIDGE_TRAFFIC
- ADT is ordered in a descending manner
- LIMIT 1 is used to obtain the highest value

In terms of length, which bridge is the longest in the US?

Query:

```
SELECT BRIDGE_ID, STRUCTURE_LEN_MT
FROM quantitative
ORDER BY STRUCTURE_LEN_MT DESC
LIMIT 1;
```

Output:

BRIDGE_ID	STRUCTURE_LEN_MT
228186	80002

- Columns BRIDGE_ID and STRUCTURE_LEN_MT are selected from table QUANTITATIVE
- STRUCTURE_LEN_MT is arranged in a descending order
- LIMIT 1 is used to obtain the “longest” value

What is the overall health of bridges in the US?

Query:

```
SELECT BRIDGE_CONDITION, COUNT(BRIDGE_ID) AS NUM_BRIDGE FROM BRIDGE_CONDITION
WHERE BRIDGE_CONDITION != ''
GROUP BY BRIDGE_CONDITION
ORDER BY NUM_BRIDGE DESC
LIMIT 1;
```

Output:

BRIDGE_CONDITION	NUM_BRIDGE
F	294991

- Columns BRIDGE_CONDITION and BRIDGE_ID are selected from table BRIDGE_CONDITION
- Make sure null values in BRIDGE_CONDITION are not included
- NUM_BRIDGE are grouped by BRIDGE_CONDITION to get the total number of bridges for each of its categories and ordered in a descending manner
- LIMIT 1 obtains the highest value in NUM_BRIDGE
- The result shows that most of the bridges are categorized as F or “Fair”

How often do the bridges get inspected on average?

Query:

```
SELECT AVG(INSPECT_FREQ_MONTHS) FROM BRIDGE_INSPECTION;
```

Output:

AVG(INSPECT_FREQ_MONTHS)
24.4136

- AVG is used to obtain the average number of months between designated inspections of the structure

What is the annual maintenance and improvement cost of each bridge?

Query:

```
SELECT BRIDGE_ID, TOTAL_IMP_COST FROM BRIDGE_IMPROVEMENT
GROUP BY BRIDGE_ID
ORDER BY TOTAL_IMP_COST DESC;
```

- Columns BRIDGE_ID and TOTAL_IMP_COST are selected from table BRIDGE_IMPROVEMENT
- TOTAL_IMP_COST is grouped by BRIDGE_ID and arranged in a descending order for each bridge
- The output shows the annual cost of each bridge

Output:

BRIDGE_ID	TOTAL_IMP_COST
474154	999999
104276	999999
104542	999999
107859	999999
96054	999999
96055	999999
96056	999999
99190	999999
99410	999999
413714	999999
278496	999999
278497	999999
278499	999999
278502	999999
278503	999999
278511	999999
278513	999999

What is the total cost of all investments in bridge maintenance and improvement in the US?

Query:

```
SELECT SUM(TOTAL_IMP_COST) FROM BRIDGE_IMPROVEMENT;
```

Output:

SUM(TOTAL_IMP_COST)
1943294414

- SUM is used to obtain the total investment cost of column TOTAL_IMP_COST

What type of bridge costs the most to maintain and improve?

Query:

```
SELECT BRIDGE_MATERIAL.STRUCTURE_TYPE, SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) AS TOTAL_IMP_COST
FROM BRIDGE_MATERIAL
INNER JOIN BRIDGE_IMPROVEMENT
ON BRIDGE_MATERIAL.BRIDGE_ID = BRIDGE_IMPROVEMENT.BRIDGE_ID
GROUP BY BRIDGE_MATERIAL.STRUCTURE_TYPE
ORDER BY SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) DESC
LIMIT 1;
```

Output:

STRUCTURE_TYPE	TOTAL_IMP_COST
2	1102303958

After Optimization:

```
SELECT BRIDGE_MATERIAL.STRUCTURE_TYPE, SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) AS TOTAL_IMP_COST
FROM BRIDGE_MATERIAL
INNER JOIN BRIDGE_IMPROVEMENT
ON BRIDGE_MATERIAL.BRIDGE_ID = BRIDGE_IMPROVEMENT.BRIDGE_ID
AND BRIDGE_IMPROVEMENT.TOTAL_IMP_COST != 0
GROUP BY BRIDGE_MATERIAL.STRUCTURE_TYPE
ORDER BY SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) DESC
LIMIT 1;
```

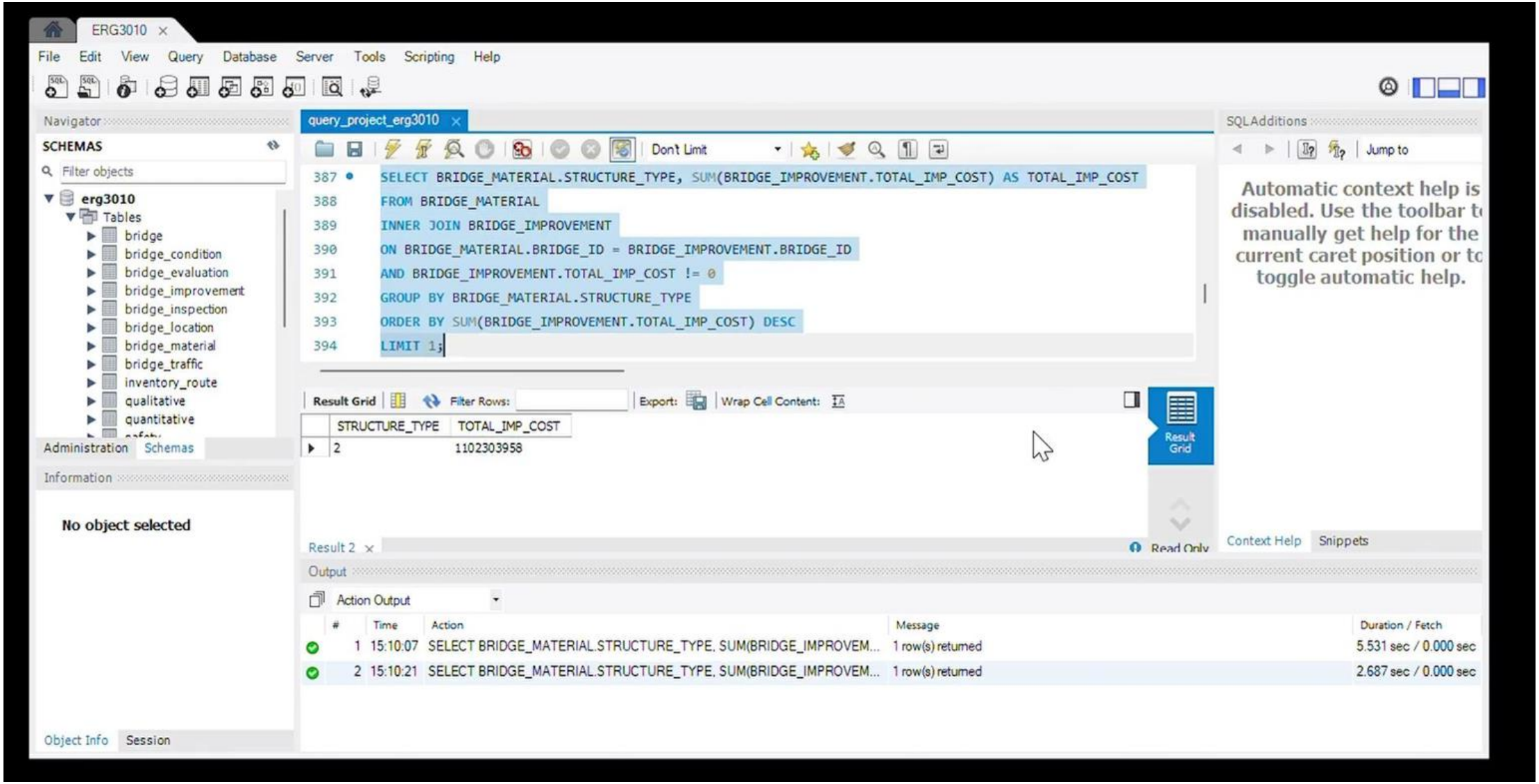
❖ *Before Optimization*

- Columns STRUCTURE_TYPE and TOTAL_IMP_COST are selected from tables BRIDGE_MATERIAL and BRIDGE_IMPROVEMENT
- INNER JOIN is used to select records with matching BRIDGE_ID in tables BRIDGE_MATERIAL and BRIDGE_IMPROVEMENT
- TOTAL_IMP_COST is grouped by STRUCTURE_TYPE and ordered in a descending manner
- LIMIT 1 is used to get the largest value in TOTAL_IMP_COST

❖ *After Optimization*

- **Filtering out records with zero TOTAL_IMP_COST values**

Optimization Video



What factors are related to the maintenance and improvement cost of bridges?

1. Structure Kind

```
SELECT BRIDGE_MATERIAL.STRUCTURE_KIND, AVG(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) AS TOTAL_IMP_COST
FROM BRIDGE_MATERIAL
INNER JOIN BRIDGE_IMPROVEMENT
ON BRIDGE_MATERIAL.BRIDGE_ID = BRIDGE_IMPROVEMENT.BRIDGE_ID
AND BRIDGE_IMPROVEMENT.TOTAL_IMP_COST != 0
GROUP BY BRIDGE_MATERIAL.STRUCTURE_KIND
ORDER BY STRUCTURE_KIND ASC;
```

STRUCTURE_KIND	TOTAL_IMP_COST
0	4980.4737
1	6614.3622
2	9355.2982
3	10628.0357
4	18834.3596
5	13703.6419
6	7774.0907
7	10917.1264
8	3742.8261
9	4369.1017

- The average cost differs with structure kind
- STRUCTURE_KIND = 4 or “Steel continuous” incurs the highest cost

What factors are related to the maintenance and improvement cost of bridges?

2. Deck Area

```
SELECT AREA_RANGE, AVG(TOTAL_IMP_COST) AS AVG_COST
FROM (
        SELECT CASE WHEN DECK_AREA <= 25000.0 then '0-25000'
                    WHEN DECK_AREA <= 50000.0 and DECK_AREA > 25000.0 then '25000-50000'
                    WHEN DECK_AREA <= 75000.0 and DECK_AREA > 50000.0 then '50000-75000'
                    WHEN DECK_AREA <= 100000.0 and DECK_AREA > 75000.0 then '75000-100000'
                    WHEN DECK_AREA <= 125000.0 and DECK_AREA > 100000.0 then '10000-125000'
                    WHEN DECK_AREA <= 150000.0 and DECK_AREA > 125000.0 then '125000-150000'
               ELSE '150000'
               END AS AREA_RANGE,
               TOTAL_IMP_COST
        FROM BRIDGE_IMPROVEMENT
) AS DT
GROUP BY AREA_RANGE
ORDER BY AVG_COST DESC;
```

AREA_RANGE	AVG_COST
125000-150000	302575.3333
150000	108071.6250
50000-75000	84590.7164
10000-125000	78788.6522
75000-100000	69645.1364
25000-50000	32313.2419
0-25000	3032.6804

- The average cost differs with deck area range
- AREA_RANGE 125000-150000 incurs the highest cost

What factors are related to the maintenance and improvement cost of bridges?

3. IMP_LEN_MT (length of structure improvement in metres)

```
SELECT LEN_RANGE, AVG(TOTAL_IMP_COST) AS AVG_COST
FROM (
        SELECT CASE WHEN IMP_LEN_MT <= 1000.0 then '0-1000'
                    WHEN IMP_LEN_MT <= 2000.0 and IMP_LEN_MT > 1000.0 then '1000-2000'
                    WHEN IMP_LEN_MT <= 2000.0 and IMP_LEN_MT > 1000.0 then '1000-2000'
                    WHEN IMP_LEN_MT <= 3000.0 and IMP_LEN_MT > 2000.0 then '2000-3000'
                    WHEN IMP_LEN_MT <= 4000.0 and IMP_LEN_MT > 3000.0 then '3000-4000'
                    WHEN IMP_LEN_MT <= 5000.0 and IMP_LEN_MT > 4000.0 then '4000-5000'
                    WHEN IMP_LEN_MT <= 6000.0 and IMP_LEN_MT > 5000.0 then '5000-6000'
                    WHEN IMP_LEN_MT <= 7000.0 and IMP_LEN_MT > 6000.0 then '6000-7000'
                    WHEN IMP_LEN_MT <= 8000.0 and IMP_LEN_MT > 7000.0 then '7000-8000'
                    WHEN IMP_LEN_MT <= 9000.0 and IMP_LEN_MT > 8000.0 then '8000-9000'
                    WHEN IMP_LEN_MT <= 10000.0 and IMP_LEN_MT > 9000.0 then '9000-10000'
               ELSE '>10000'
               END AS LEN_RANGE,
               TOTAL_IMP_COST
        FROM BRIDGE_IMPROVEMENT
) AS DT
GROUP BY LEN_RANGE
ORDER BY AVG_COST DESC;
```

LEN_RANGE	AVG_COST
9000-10000	302591.0000
3000-4000	196967.0377
2000-3000	179948.6000
4000-5000	177142.5294
7000-8000	140922.0000
>10000	115348.4348
5000-6000	108614.9000
8000-9000	73769.2500
1000-2000	57828.7291
0-1000	2990.1488
6000-7000	254.6000

- The average cost differs with length range
- LEN_RANGE 9000–10000 incurs the highest cost

What factors are related to the maintenance and improvement cost of bridges?

4. Bridge Condition

```
SELECT BRIDGE_CONDITION, AVG(TOTAL_IMP_COST) AS AVERAGE_COST
FROM (BRIDGE_IMPROVEMENT AS TABLE1), (BRIDGE_CONDITION AS TABLE2)
WHERE TABLE1.BRIDGE_ID = TABLE2.BRIDGE_ID AND TOTAL_IMP_COST != 0
GROUP BY BRIDGE_CONDITION
ORDER BY AVG(TOTAL_IMP_COST) DESC;
```

BRIDGE_CONDITION	AVERAGE_COST
N	140136.1497
P	10998.9972
F	10852.6807
G	8446.6236

- The average cost differs with bridge condition
- BRIDGE_CONDITION = N or “Neutral” incurs the highest cost
- BRIDGE_CONDITION = G or “Good” incurs the least cost

What factors are related to the maintenance and improvement cost of bridges?

5. Deck Condition

```
SELECT DECK_CONDITION, AVG(TOTAL_IMP_COST) AS AVERAGE_COST
FROM (BRIDGE_IMPROVEMENT AS TABLE1), (BRIDGE_CONDITION AS TABLE2)
WHERE TABLE1.BRIDGE_ID = TABLE2.BRIDGE_ID AND TOTAL_IMP_COST != 0
GROUP BY DECK_CONDITION
ORDER BY AVG(TOTAL_IMP_COST) DESC;
```

DECK_CONDITION	AVERAGE_COST
9	21262.0755
5	14308.3258
6	13977.9769
4	10009.6136
7	9646.9960
8	7963.1208
3	4767.0980
0	4612.9947
1	4566.7813
2	4371.6239

- The average cost differs with the deck condition
- DECK_CONDITION = 9 or “EXCELLENT CONDITION” incurs the highest cost

What factors are related to the maintenance and improvement cost of bridges?

6. Superstructure Condition

```
SELECT SUPERSTRUCTURE_CONDITION, AVG(TOTAL_IMP_COST) AS AVERAGE_COST
FROM (BRIDGE_IMPROVEMENT AS TABLE1),(BRIDGE_CONDITION AS TABLE2)
WHERE TABLE1.BRIDGE_ID = TABLE2.BRIDGE_ID AND TOTAL_IMP_COST != 0
GROUP BY SUPERSTRUCTURE_CONDITION
ORDER BY AVG(TOTAL_IMP_COST) DESC;
```

SUPERSTRUCTURE_CONDITION	AVERAGE_COST
9	18041.8802
5	15389.8287
6	12047.0904
1	10798.8588
8	10207.9248
4	10206.2695
3	9816.2918
7	9423.8039
0	4635.1359
2	3089.5689

- The average cost differs with superstructure condition
- SUPERSTRUCTURE_CONDITION = 9 or “EXCELLENT CONDITION” incurs the highest cost

What factors are related to the maintenance and improvement cost of bridges?

7. Service On

```
SELECT SERVICE_ON, AVG(TOTAL_IMP_COST) AS AVERAGE_COST
FROM (BRIDGE AS TABLE1), (BRIDGE_IMPROVEMENT AS TABLE2)
WHERE TABLE1.BRIDGE_ID = TABLE2.BRIDGE_ID AND TOTAL_IMP_COST != 0
GROUP BY SERVICE_ON
ORDER BY AVG(TOTAL_IMP_COST) DESC;
```

SERVICE_ON	AVERAGE_COST
2	719793.2500
3	478852.1667
4	51445.2400
7	15242.0455
5	10630.2811
1	10082.2877
6	4281.6602
8	4024.9583
0	3871.0000
9	167.6667

- The average cost differs with the service “on” the bridges
- SERVICE_ON = 2 or “Railroad” incurs the highest cost

What factors are related to the maintenance and improvement cost of bridges?

8. Service Under

```
SELECT SERVICE_UND, AVG(TOTAL_IMP_COST) AS AVERAGE_COST
FROM (BRIDGE AS TABLE1), (BRIDGE_IMPROVEMENT AS TABLE2)
WHERE TABLE1.BRIDGE_ID = TABLE2.BRIDGE_ID AND TOTAL_IMP_COST != 0
GROUP BY SERVICE_UND
ORDER BY AVG(TOTAL_IMP_COST) DESC;
```

SERVICE_UND	AVERAGE_COST
8	40765.4290
3	35263.5145
9	33460.9103
6	23311.5955
4	21197.4670
7	18742.3532
1	16913.3659
2	16744.6850
0	11441.9733
5	7974.1747

- The average cost differs with the service “under” the bridges
- SERVICE_UND = 8 or “Fourth Level (Interchange)” incurs the highest cost

Which state invests the most in the maintenance and improvement of bridges?

Query:

```
SELECT BRIDGE_LOCATION.STATE_CODE, SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) AS TOTAL_INVEST
FROM BRIDGE_LOCATION
INNER JOIN BRIDGE_IMPROVEMENT
ON BRIDGE_LOCATION.BRIDGE_ID = BRIDGE_IMPROVEMENT.BRIDGE_ID
GROUP BY BRIDGE_LOCATION.STATE_CODE
ORDER BY SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) DESC
LIMIT 1;
```

Output:

STATE_CODE	TOTAL_INVEST
28	890061727

- The corresponding state is Mississippi

After Optimization:

```
SELECT BRIDGE_LOCATION.STATE_CODE, SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) AS TOTAL_INVEST
FROM BRIDGE_LOCATION
INNER JOIN BRIDGE_IMPROVEMENT
ON BRIDGE_LOCATION.BRIDGE_ID = BRIDGE_IMPROVEMENT.BRIDGE_ID
AND BRIDGE_IMPROVEMENT.TOTAL_IMP_COST != 0
GROUP BY BRIDGE_LOCATION.STATE_CODE
ORDER BY SUM(BRIDGE_IMPROVEMENT.TOTAL_IMP_COST) DESC
LIMIT 1;
```

❖ *Before Optimization*

- Columns STATE_CODE and TOTAL_IMP_COST are selected from tables BRIDGE_LOCATION and BRIDGE_IMPROVEMENT
- INNER JOIN is used to select records with matching BRIDGE_ID in tables BRIDGE_MATERIAL and BRIDGE_IMPROVEMENT
- TOTAL_IMP_COST is grouped by STRUCTURE_TYPE and ordered in a descending manner
- LIMIT 1 is used to get the largest value in TOTAL_IMP_COST

❖ *After Optimization*

- **Filtering out records with zero TOTAL_IMP_COST values**

Optimization Video

What kind of materials are most used in bridge maintenance and improvement?

Query:

```
SELECT STRUCTURE_KIND, COUNT(BRIDGE_ID) AS NUM_BRIDGE FROM BRIDGE_MATERIAL
WHERE BRIDGE_ID IN (SELECT BRIDGE_ID FROM BRIDGE_IMPROVEMENT WHERE TOTAL_IMP_COST != 0)
GROUP BY STRUCTURE_KIND
ORDER BY NUM_BRIDGE DESC
LIMIT 1;
```

Output:

STRUCTURE_KIND	NUM_BRIDGE
1	63235

- Columns STRUCTURE_KIND and BRIDGE_ID are selected from table BRIDGE_MATERIAL
- BRIDGE_ID in BRIDGE_MATERIAL must match BRIDGE_ID in BRIDGE_IMPROVEMT where 0 values in TOTAL_IMP_COST are not included
- NUM_BRIDGE, sum of BRIDGE_ID are grouped by STRUCTURE_KIND to get the total number of bridges for each of its category and ordered in a descending manner
- LIMIT 1 obtains the highest value in NUM_BRIDGE
- The results show that the most used material is 1 or “Concrete”

Extra Question

- We investigate the **factors that are related to the health of the bridges**

- We consider the following factors:
  1. Average Daily Traffic (ADT)
  2. Structure kind
  3. Age (current year – year built)
  4. Maintenance responsibility
  5. Fracture

What factors are related to the health of the bridges?

1. ADT (Average Daily Traffic)

```
SELECT BRIDGE_CONDITION, AVG(ADT) AS AVERAGE_ADT
FROM (BRIDGE_CONDITION AS t1), (BRIDGE_TRAFFIC AS t2)
WHERE t1.BRIDGE_ID = t2.BRIDGE_ID AND BRIDGE_CONDITION != ''
GROUP BY BRIDGE_CONDITION;
```

BRIDGE_CONDITION	AVERAGE_ADT
G	7814.216170497031
F	8564.60026577082
P	3809.4190224512004
N	2012.4806048652204

- The bridge condition differs with the average daily traffic
- BRIDGE_CONDITION = F or “Fair” has the heaviest ADT

What factors are related to the health of the bridges?

2. Structure Kir

```
SELECT STRUCTURE_KIND, BRIDGE_CONDITION
FROM (BRIDGE_MATERIAL AS t1), (BRIDGE_CONDITION AS t2)
WHERE t1.BRIDGE_ID = t2.BRIDGE_ID
AND t2.BRIDGE_CONDITION != ''
GROUP BY STRUCTURE_KIND
ORDER BY STRUCTURE_KIND;
```

STRUCTURE_KIND	BRIDGE_CONDITION
0	G
1	F
2	P
3	F
4	F
5	G
6	G
7	P
8	F
9	P

- The bridge condition differs with the structure kind

What factors are related to the health of the bridges?

3. Age

```
SELECT BRIDGE_CONDITION, YEAR_BUILT, (2021-YEAR_BUILT) AS AGE_SINCE_BUILT
FROM (BRIDGE AS TABLE1), (BRIDGE_CONDITION AS TABLE2)
WHERE TABLE1.BRIDGE_ID = TABLE2.BRIDGE_ID AND BRIDGE_CONDITION != "" AND YEAR_BUILT != 0
ORDER BY AGE_SINCE_BUILT;
```

BRIDGE_CONDITION	YEAR_BUILT	AGE_SINCE_BUILT
G	2021	0
G	2021	0
G	2021	0
G	2021	0
G	2021	0
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1
G	2020	1

- The bridge condition differs with the year the bridge was built
- Bridges built more recently are in better condition i.e. YEAR_BUILT = 2021 corresponds to BRIDGE_CONDITION = G or “Good”

What factors are related to the health of the bridges?

4. Maintenance Responsibility

```
SELECT MAINTENENCE_RESPONSIBILITY, BRIDGE_CONDITION
FROM bridge_condition
WHERE BRIDGE_CONDITION != ''
GROUP BY MAINTENENCE_RESPONSIBILITY
ORDER BY MAINTENENCE_RESPONSIBILITY;
```

- The bridge condition differs with the agency responsible for its maintenance

MAINTENENCE_RESPONSIBILITY	BRIDGE_CONDITION
0	N
1	F
2	P
3	G
4	P
11	F
12	F
21	F
25	F
26	P
27	P
31	F
32	F
56	F
57	F
58	G
59	F

What factors are related to the health of the bridges?

5. Fracture

```
SELECT FRACTURE, BRIDGE_CONDITION
FROM (bridge_condition AS TABLE1), (bridge_inspection AS TABLE2)
WHERE TABLE1.BRIDGE_ID = TABLE2.BRIDGE_ID AND BRIDGE_CONDITION != '' AND FRACTURE != ''
GROUP BY FRACTURE
ORDER BY FRACTURE;
```

FRACTURE	BRIDGE_CONDITION
N	G
N00	F
Y00	P
Y01	P
Y03	P
Y06	P
Y12	G
Y13	F
Y14	F
Y15	P
Y18	F
Y21	F
Y23	F
Y24	F
Y48	G

- The bridge condition differs with its fracture critical details:
  1. Need for special inspection (Y/N)
  2. Number of months between inspection

Performance Evaluation

In the previous questions, we have managed to **improve the efficiency** of the query by:

1. Replacing INNER JOIN with subquery
2. Using “WHERE” instead of “HAVING”
3. Avoiding “IS NULL” and “IS NOT NULL” by replacing them with the empty string
4. Filtering out unwanted records before implementing GROUP BY

Work Assignment & Contribution

- **Karen Riady (118010496):** Designed ERD, built tables, wrote queries to answer questions, delivered the presentation
- **Glenys Charity Lion (119010528):** Designed ERD, built tables, wrote queries to answer questions, delivered the presentation
- **Richard Cornelius Suwandi (119010540):** Designed ERD, built tables, wrote queries to answer questions, delivered the presentation

Note: Every team member contributed equally to this project


- Thank You -