LCA Case Study for O'Hare International Airport Taxiway A &B Rehabilitation

Presented by:

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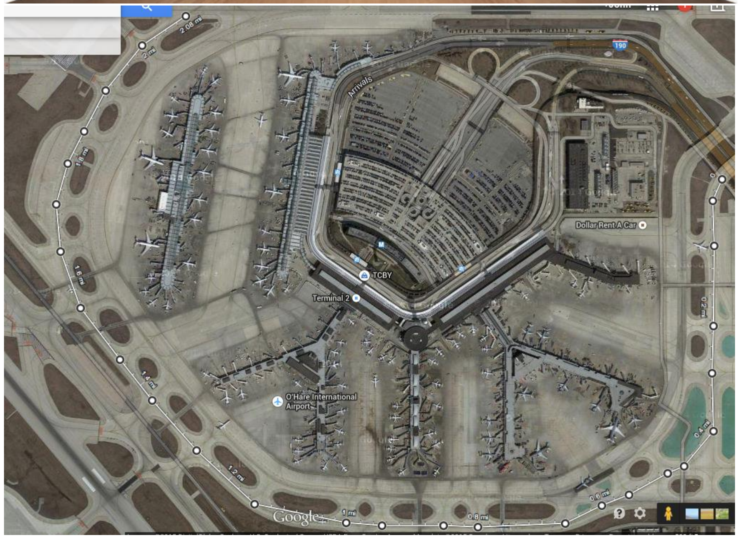
Overview

- Criticality of Airports
- LCA-AIR Overview
- Taxiway A&B Background
- Rehabilitation Options
- Results
- Future Research


(www.wallpapersxl.com)



- Acknowledge: Mohammed Sawalha, Michael Sladek, Dr. Hasan Ozer, Dr. Jeffery Roesler and O'Hare Modernization Program

Criticality of Airports

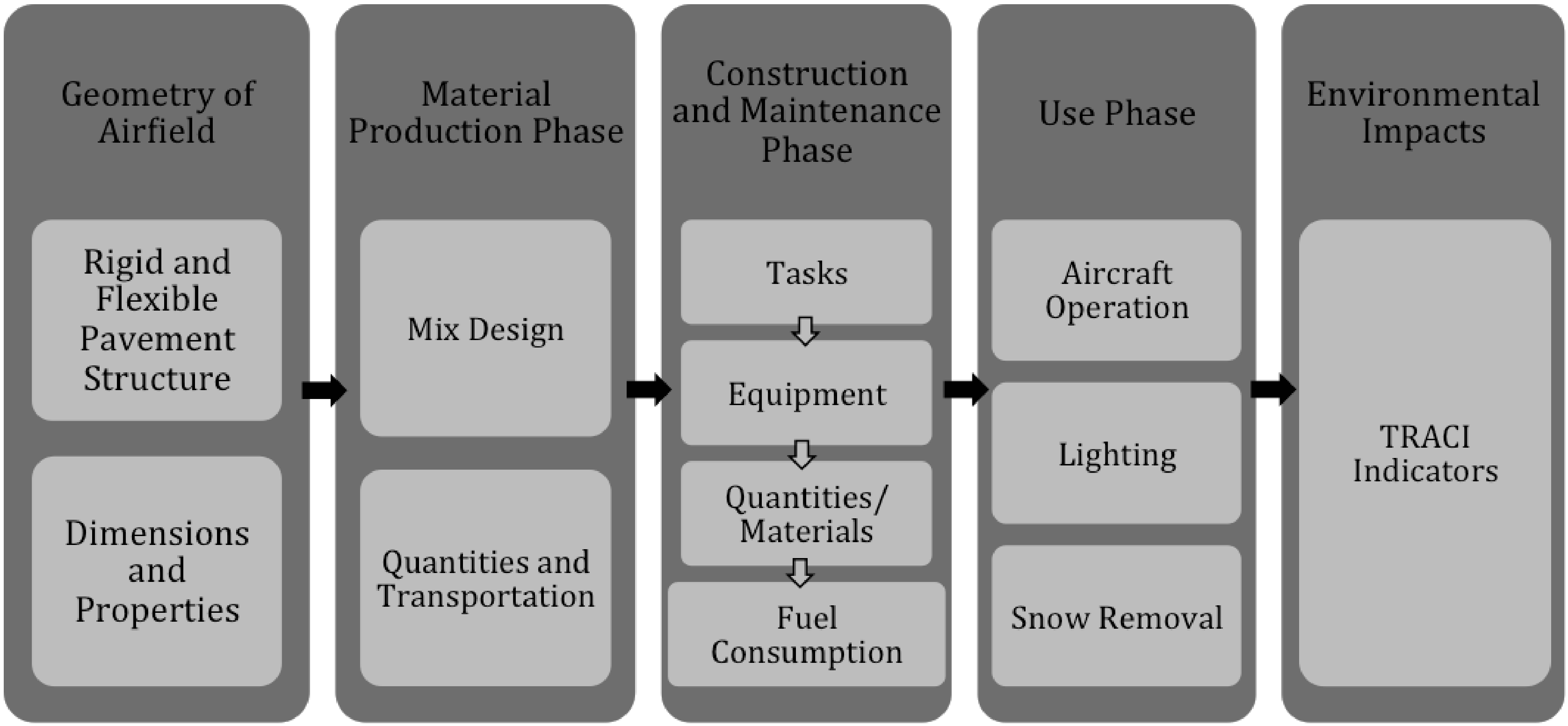
- Airports process 3.3B passengers w/3.6T passenger-miles
- Airports process 55M short-tons freight annually
- Accounts for 8.2% of Transportation Sectors greenhouse gas (GHG) emissions (U.S.)
- Accounts for 3% of world GDP


(www.wired.com)

Limitations and Assumptions

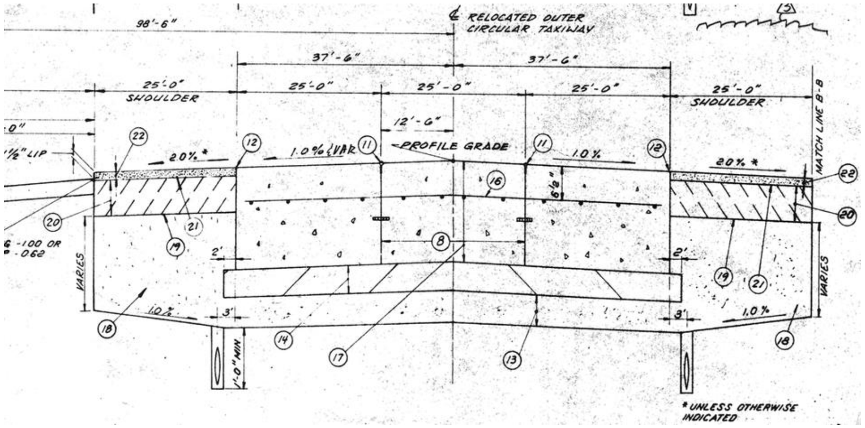
- Jet fuel consumption is modeled as kerosene combustion in industrial equipment.
- Construction/mx equipment only consider the diesel fuel consumed
- Feedstock energy is not considered.
- 90% of the maximum take off weight was used for aircraft.
- The aircraft fuel consumption during flight is constant. Air resistance is constant.
- Airfield lights run 12 hrs/day
- Snow removal consumes fuel but deicing chemical impacts are not included in the LCA.
- 5-mile haul distance for concrete (PCC) and asphalt (AC) for initial construction.
- IRI adapted from roadways
- Sweeping assumed to occur 1 per week.

LCA-AIR Tool Overview

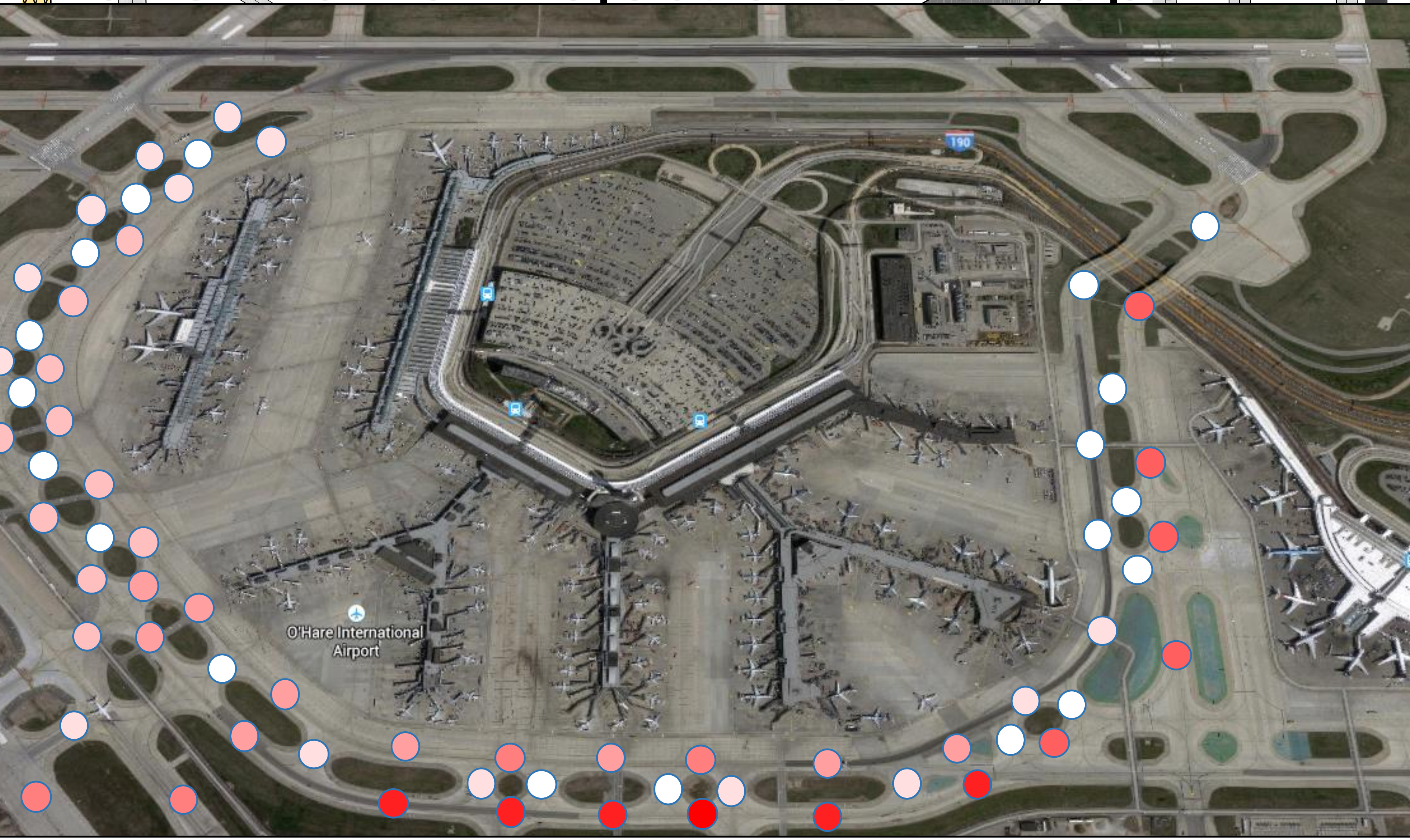


Taxiway A & B

- Constructed 1986 - 1988
  - 11,088’ by 75’ (25’ x 25’ slab)
  - 2011 PCI <75 (~40%<50)
    - Longitudinal/transverse crack center lane (primary)
  - Mx plan called for 75% reconstruction by 2013
    - Significant mx on 25%
  - Issues with surface drainage and probable underdrain failure
  - High vol of medium aircraft Group 1-4; <300 kips (90% traffic)



2018 Traffic Projections - Groups 1 - 4

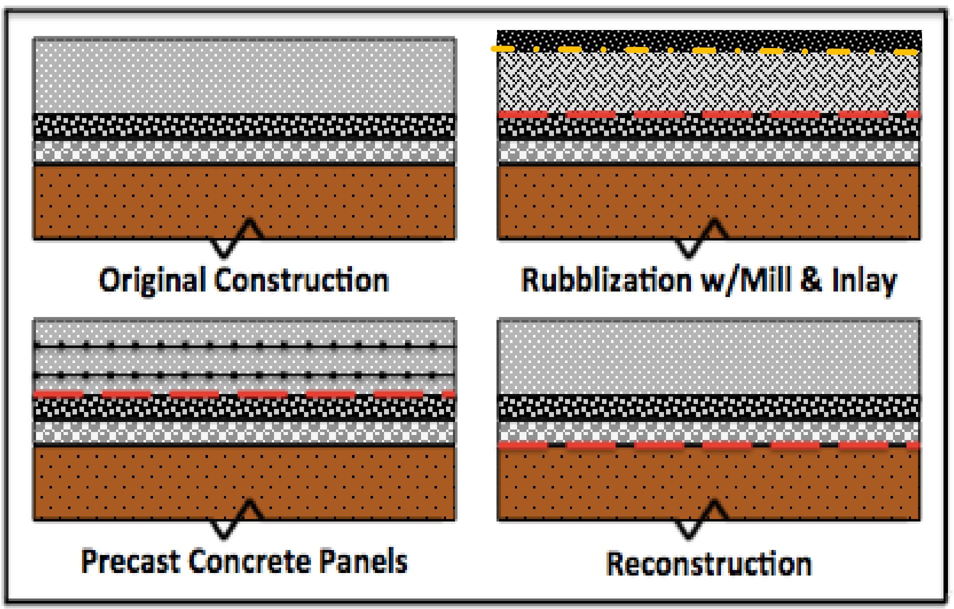


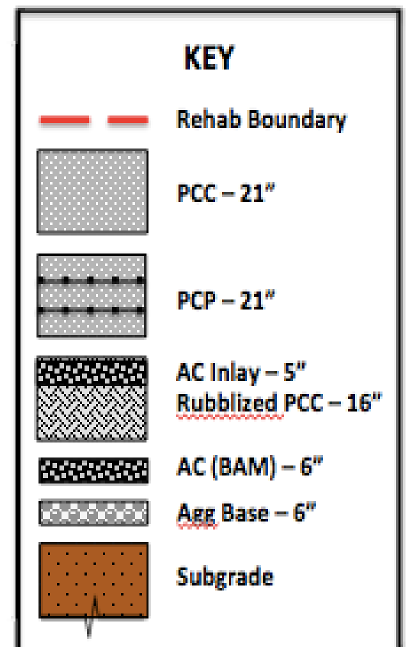
Legend (Number of Projected Operations):

- 0 – 50,000
- 50,001 – 100,000
- 100,001 – 150,000
- 150,001 – 200,000
- 200,001 – 250,000
- 250,001 – 300,000
- 300,001 – 350,000
- 350,001 – 400,000
- 400,001 – 450,000

Rehabilitation Options

- 3 selected for further analysis
  - Rubbilization, Precast Concrete Panel (PCP), Reconstruction
  - Impact to airlines (closures), longevity and elevation constraints to adjacent features
- Analysis included LCA as another decision data tool





LCA Implementation

- Rehabilitation occurs at the 30 yr point
  - Extend pavement life to 50 yrs (20 yrs more)
- Rubbilization with mill/inlay receives mill/inlay 10 yrs later
- PCP & full-depth reconstruction has 20 yrs design life
- Scope include 200 keel section slabs on southern side of each taxiway (125,000 ft^2)
- Material production (MP) and **construction, maintenance and rehabilitation (CMR)** used functional unit of yd^2
- Use phase used functional unit pound-mile

Material Production and Initial Construction

- MP impacts are the same for each strategy
- Initial construction equipment impacts
  - Fuel consumption for PCC: 15,794 gal
  - Fuel consumption for AC: 11,899 gal

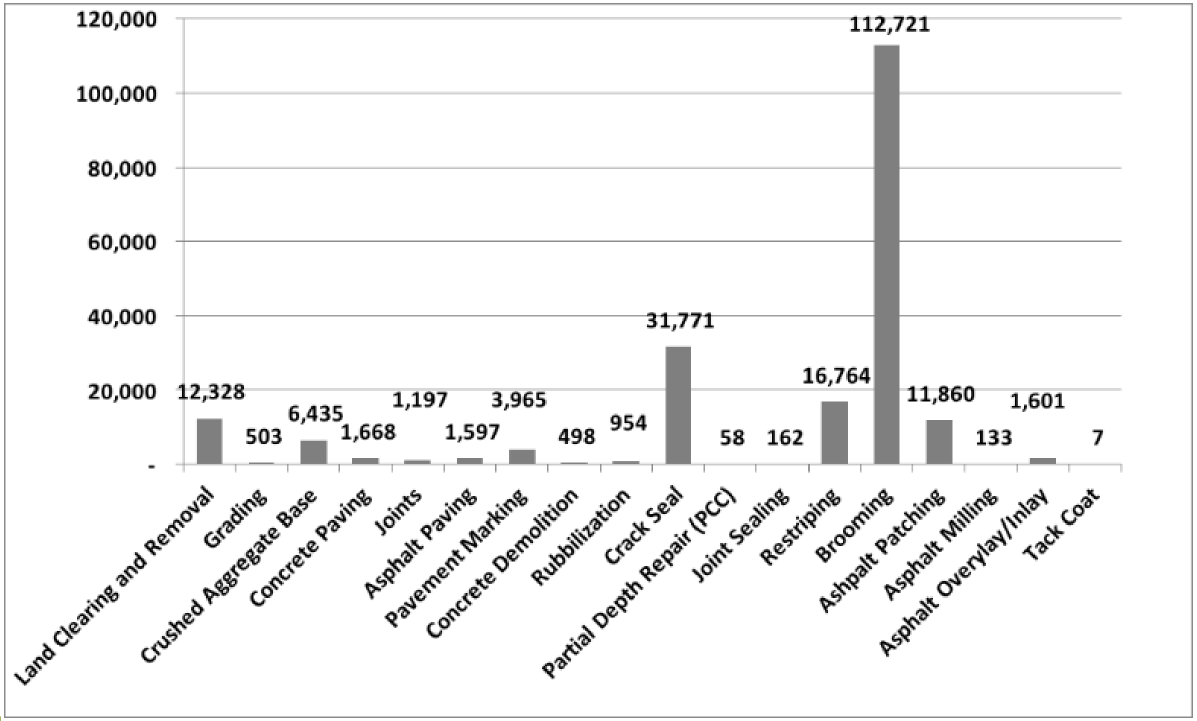
- Mx activities vary greatly around aircraft (24/7/365)
- Activities were aggregated over time as occurred at specific intervals for analysis

Developed Mx Schedule

- PCC
  - Restriping airfield markings – every ten years
  - Joint and crack sealing – every eight years
  - Full and partial depth repairs – every fifteen years
  - Brooming – every other day
- AC & AC Shoulders
  - Restriping airfield markings – every ten years
  - Crack sealing – every ten years
  - Asphalt patching – every fifteen years
  - Mill/inlay – every fifteen years
  - Mill/inlay – 10 years after the initial rubblization with mill/inlay section

CMR Phase - Rubblization w/Mill & Inlay

- Rubblization consumed: 954 gal
- AC inlays (no shoulders) consumed: 553
- Brooming – critical; 1/5 days shows a 10% redux (weigh FOD!!)
- Crack sealing time & energy intensive
- Total fuel consumed: 204.6K gals



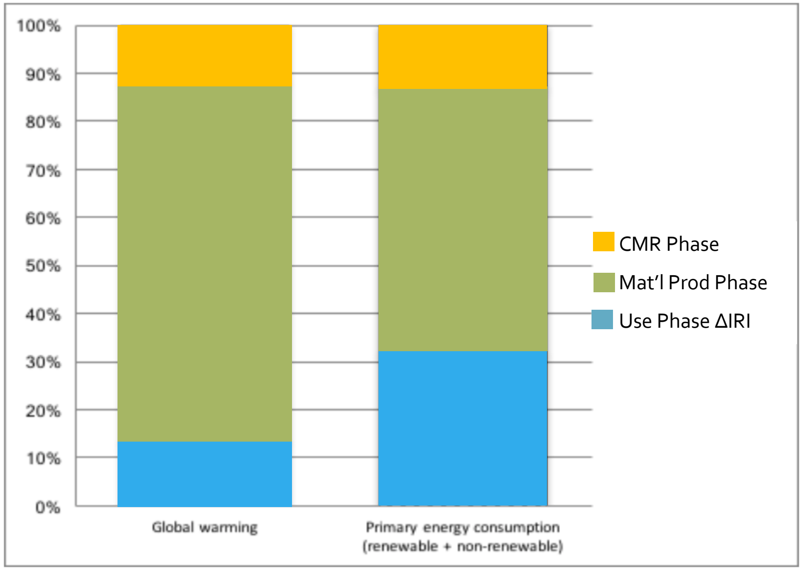
CMR Phase - Rubblization w/Mill & Inlay

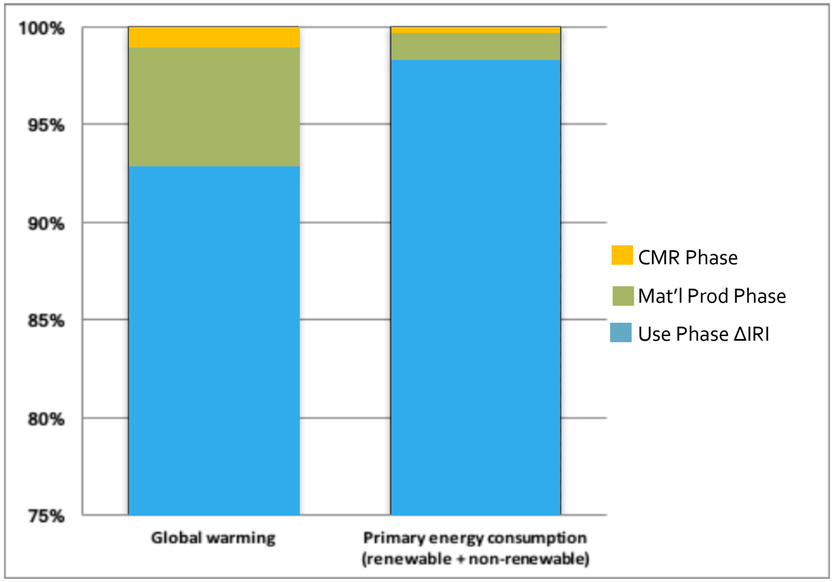
- Reused/left in place the most material of strategies
  - Used 24% less energy than PCP
  - Used 30% less energy than reconstruction

  - Used 43% less GWP than PCP
  - Used 37% less GWP than reconstruction

CMR Phase - Rubblization w/Mill & Inlay

- Unlike roadways, increase fuel consumption doesn't dominate….limited time for tire pavement interaction
- Including fuel consumed in flight…Use phase is more dominant than roadways





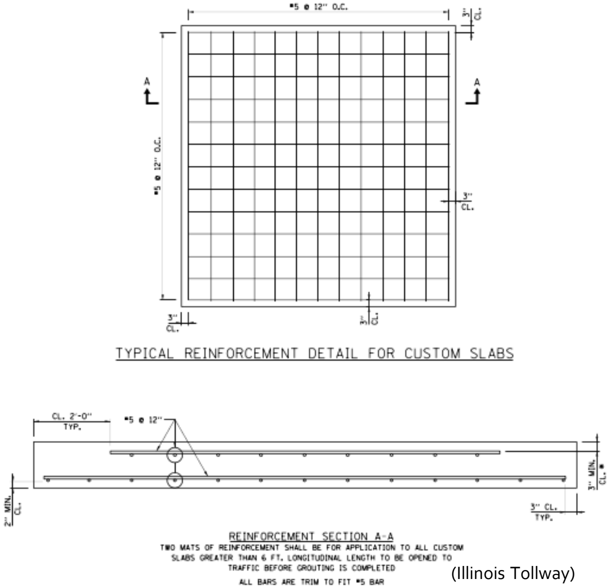
CMR Phase - Precast concrete Panels

- Slab lift-out method
- Additional 523 gal demolition of PCC
- PCP placement added 2,973 gal
  - Steel and leveling sand added work/material to impacts

- Diamond grinding (whole area) added 761 gal
  - Work w/manufacture can increase tolerance = spot grinding
- Reduction in crack sealant and patching operations
- Total fuel consumed CMR: 206.1K gal (2,052 gal more than rubbilization)

CMR Phase - Precast concrete Panels

- Cast on airfield
  - Used 8% less energy than reconstruction
    - Installation is less intensive
  - Used 9% more GWP than reconstruction
    - Attributed to the two mats of stee in the PCP
- Open to traffic after placement (no curing)

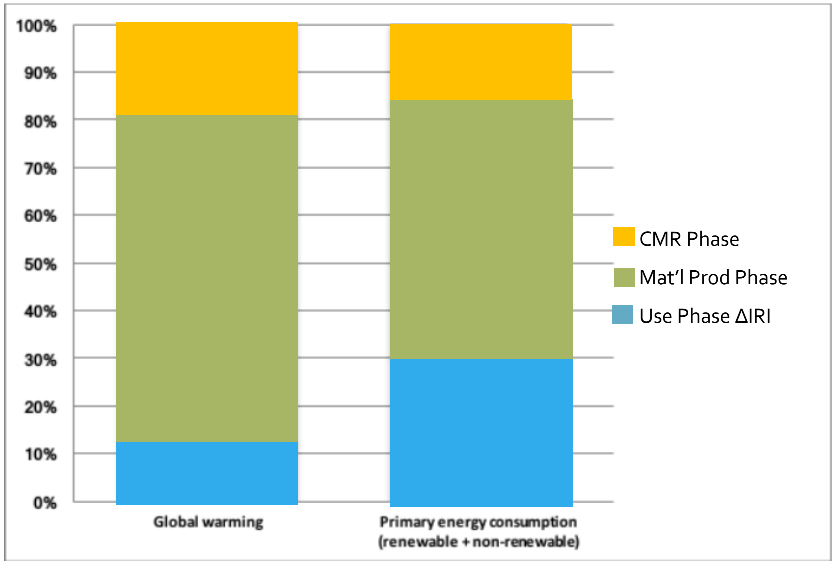


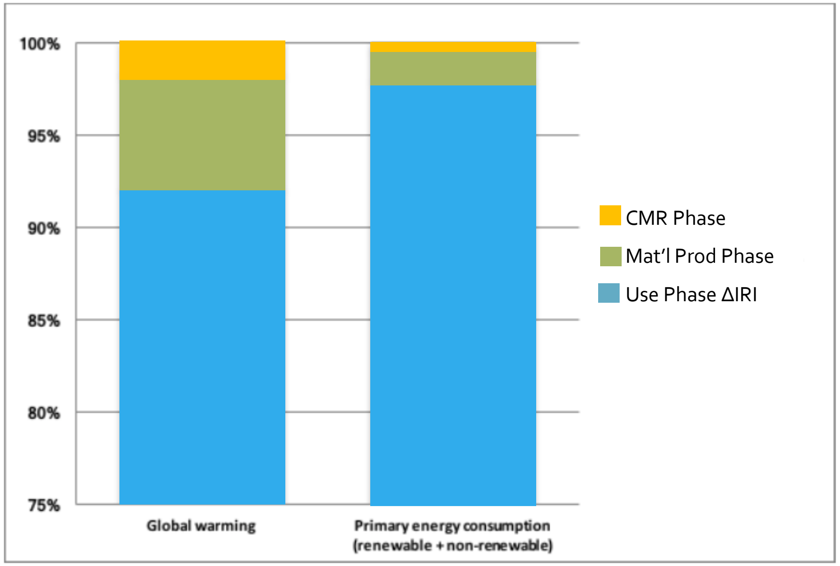
(Illinois Tollway)


(Tsubokawa Y. , 2015)

CMR Phase - Precast concrete Panels

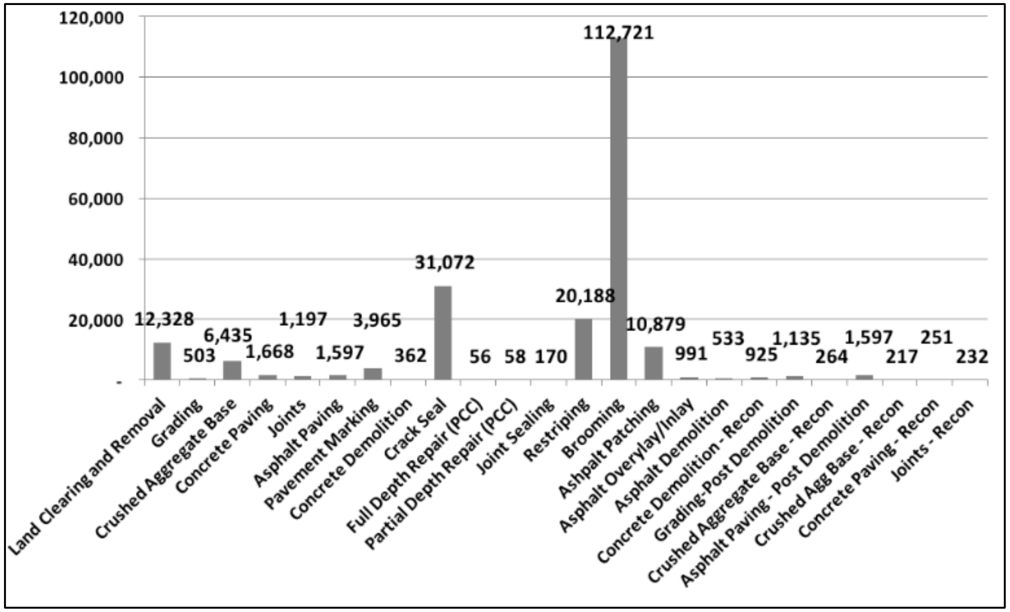
- Chart shows and increase in the CMR phase impacts
  - Full-depth PCC and steel



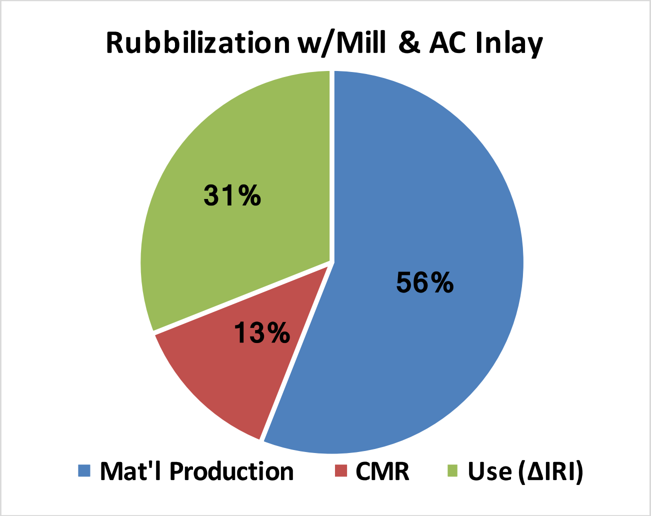


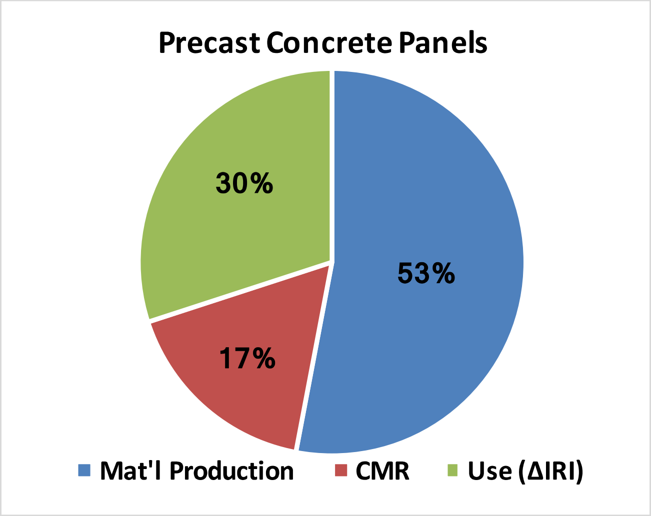
CMR Phase - Reconstruction

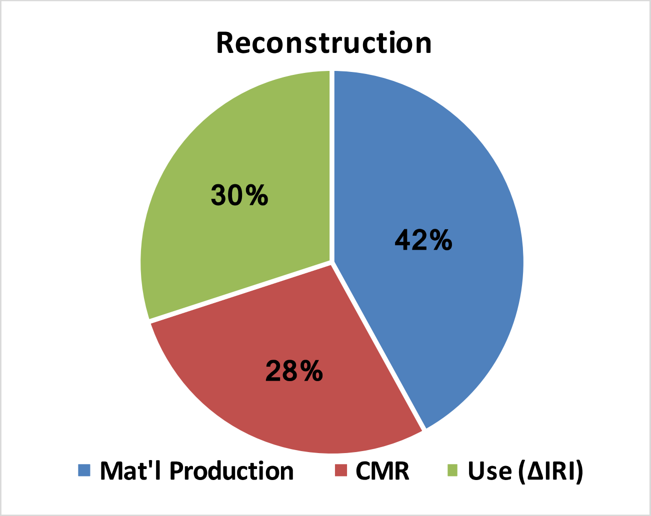
- Most material removed
  - Removal of PCC, AC base course and aggregate subbase
  - Hydraulic hammer on excavator - rapid breakage and removal
- More activities, but fairly rapid….except curing!
  - Can't reopen next day
- Total fuel: 205.2K gal
  - 1,175 gal more than rubbilization
  - 877 less than PCP



Strategy Summary Breakdown Per Phase







Quantified Impacts

Rank	Strategy	Impact category	Unit	Total Impact Per yd^2	Total Impact Per lb-mile	Total Impact Per yd^2 (ΔIRI Only)	Total Impact Per lb-mile (ΔIRI Only)
1	**Rubblization w/Mill/AC Inlay**	Global warming	kg CO2 eq	2.395E+03	4.31E-10	2.00E+02	3.93E-11
2	**Reconstruction**	Global warming	kg CO2 eq	2.409E+03	4.73E-10	2.15E+02	4.22E-11
3	**Precast Concrete Panel**	Global warming	kg CO2 eq	2.413E+03	4.74E-10	2.18E+02	4.29E-11

Rank	Strategy	Impact category	Unit	Total Impact Per yd^2	Total Impact Per lb-mile	Total Impact Per yd^2 (ΔIRI Only)	Total Impact Per lb-mile (ΔIRI Only)
1	**Rubblization w/Mill/AC Inlay**	Primary energy consumption (renewable + non-renewable)	TJ	0.1861	3.58E-08	0.00518	1.02E-09
2	**Precast Concrete Panel**	Primary energy consumption (renewable + non-renewable)	TJ	0.1863	3.66E-08	0.00540	1.06E-09
3	**Reconstruction**	Primary energy consumption (renewable + non-renewable)	TJ	0.1864	3.66E-08	0.00547	1.07E-09

Further Research Areas

- **LCA Tools for Airports!**
- Develop complex components of use phase
  - Aircraft tire-pavement interaction
  - Roughness impacts on fuel burn
  - Air resistance/density for in-flight
  - Fuel burn intensity for various flight status
  - Establish allocation standard for aircraft fuel burn
    - Attribute ½ and ½ to each airfield … or ... other method to account for fuel burn impacts
  - Partnership with aircraft manufacturers
- Account for tug (plane & freight) and ground equipment
- End of life phase – unique opportunities and timeline which differ from roadways

Questions

Backup Slides

LCA-AIR Use Phase - Aircraft Fuel Consumption

- Vehicle tire-pavement interaction is heavily researched for fuel consumption increase from ΔIRI … not the case aircraft tire-pavement interaction
  - No ‘IRI’ models for airfields
  - Adapted an IRI deterioration model from roadways
- Aircraft are only on pavement for ~30 min/flight
  - Limited and short-sighted accounting for combustion of JP-8
  - Significant amount of fuel consumption is take-off and cruising (no tire pavement interaction!!)
  - Fuel burn intensity for short vs. long flights