Case Study Analysis of the Sequencing of Asphalt Paving for the San Luis Obispo Airport Runway Rehabilitation Project

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The following analysis of the San Luis Obispo Runway Rehabilitation Project is an examination of the asphalt paving sequence used to pave the 11-29 Runway and associated taxiways. The primary objective of this case study analysis is to gain insight as to how the pavement sequencing could have been done differently to decrease the potential for joint compaction issues between paving areas while still maintaining high efficiency and adhering to work limitations. To address issues encountered with the original paving sequence related to joint compaction, there are two alternative paving plans that this analysis will apply: wider paving areas with less longitudinal jointing and longer work closures. In contrasting the alternative pavement sequencing methods to the original paving sequence of the project, it will be possible to determine if a more efficient method could have been used and overall look at how the knowledge gained throughout this analysis could be applicable in future asphalt paving operations. The research methodology used will combine the development of quantitative data as related to asphalt placement rates and work segments compared across different sequencing phases, and the collection of qualitative data gathered through semi-structured interviews with members of the project team and industry members.

Key Words: Asphalt Paving, Joint Compaction, Airport Construction, Sequencing, Site Logistics

Introduction

The San Luis Obispo Runway 11-29 Rehabilitation Project was proposed by the City of San Luis Obispo in conjunction with the Federal Aviation Administration and the San Luis Obispo County Regional Airport (SLOCRA). This project utilized a Construction Manager At-Risk delivery method (CMAR) meaning that San Luis Obispo Airport worked in conjunction with the Construction Manager, Adam Souza, on behalf of Granite Construction and then designed by the engineering firm—Mead & Hunt. The general contractor for the project was Granite Construction Company which executed the main scope of the project in addition to electrical subcontractor Lee Wilson Electric.

The overall scope of the project is primarily consisting of the rehabilitation of Runway 11-29 and complete replacement of runway electrical fixtures and equipment. Runway 11-29 received a 4-inch mill and 4-inch overlay, apart from the Runway 29 end displaced threshold area and Runway 11 blast pad. The Runway 29 end displaced threshold received a 2-inch mill and 6-inch overlay to connect a structurally deficient pavement section, essentially serving as the inspiration for the rehabilitation. The Runway 11 end blast pad received a 2.25-inch mill and 2.25-inch overlay. Taxiway A at the 29 end received a 2-inch mill and variable depth overlay to transition from the new runway grade to existing taxiway grade. Additionally, all incandescent runway edge light fixtures were replaced with LED light fixtures and all runway guidance signs and runway distance remaining (RDR) signs replaced with new LED signs. Any associated runway cable and conduit was also replaced. The primary challenge of the project was logistical constraints that required the airport to remain open and operational between 6am to 6pm every day, therefore only allowing for construction to occur between 6pm to 6am Sunday evenings through Friday mornings. If the airport was not able to open on time or there were arrival or departure delays due to construction, there were major monetary damages enacted.

To mitigate these potential damages, the original paving sequence was broken down into each of the aprons and taxiways, the two blast pad areas in front of and at the end of the runway, and the runway broken up into twelve strips to be milled and placed in a night. While this method appeared to be successful as paving was completed within the time limit, there were several issues that arose with joint compaction between the paving strips on the runway which the engineers for the project, Mead & Hunt, ultimately had to sign off on. Additionally, the paving had to be completed well before 6am as to let the striping subcontractor re-stripe the new pavement before the airport could open. The purpose for this case-study analysis is to look at how the pavement sequencing for this project could have been differently orientated as to eliminate the number of jointed connections between paving areas based on the observed production rates for this project and required work hours.

SLOCRAA and FAA Construction Requirements

The County of San Luis Obispo is required to adhere to standards contained in the various Federal Aviation Administration (FAA) Advisory Circular (AC) 150 series as part of the Airport's grant assurance obligations in return for accepting federal funds under the Airport Improvement Program (AIP) for the design and construction of airport projects (San Luis Obispo County Regional Airport, 2020). All requirements related to the construction safety and phasing of this project are contained in FAA AS 150/5370-2G, Chapter 2, Section 2.4. In conformity with section 20.13.1, "The Contractor must at all tines conduct work in conformance with requirements of the County and the FAA" meaning that the following construction safety and phasing requirements should be analyzed and considered in stride with any proposed alternatives to the original phasing plan (FAA, 2017).

One of the primary considerations in analyzing changes to the phasing of this project is labor availability and access to the jobsite. Due to the elevated level of security always demanded at this location, unless escorted by Airport Operations personnel or the Resident Project Representative, each Contractor foreman or supervisory personnel working at a construction site inside the OA (Operating Area) must obtain an Airport Security Badge. To qualify for an Airport Security Badge, personnel must possess two forms of identification, pass a criminal background check, and clear a security threat assessment, with the background and assessment process taking more than 30 days. The foreman and other badged personnel are responsible for escorting their employees and material deliveries while on the jobsite, assuring no breached of Airport security program occur.

After the completion of each working shift, Airport Operations personnel shall conduct a post-construction inspection determining whether the Airport is safe for aircraft operations in which significant penalties have been established for delay in opening or, additionally flight scheduling. If the Contractor's personnel fail to comply with any Airport rule or outlined provision, the work will cease until the violation is corrected. Violation of rules and regulations are subject to Airport enforcement policies and Notice of Violation incurred by the Contractor could incur penalties ranging from $1,000 for the first offense and increasing per offense. In conjunction with the contract, there are additional penalties associated with each half-hour delay of the opening of the SLOCRA and each additional delay or cancellation of a flight.

Literature Review

Phasing of work is critical with any project and correlates to cost, scheduling, labor, equipment usage, and overall site logistics. The phasing of an airport project is especially critical as there is an increased level of coordination required when considering flight schedules, FAA requirements, and site security. As pertaining to the phasing of a runway asphalt resurfacing project, most airports operate with a single runway therefore requiring "the majority of runway resurfacing projects to be completed in short night shifts with the runway returned to operation condition each morning which requires a high production capacity to complete as much work as practicable in each work period and significant redundancy to reduce the risk of the runway not being serviceable at the end of each work period" (White, 2019). While this redundant paving sequence is common among airport resurfacing projects, there are other issues that were observed because of this sequence, prompting this research such as issues with joint compaction rising from the continuously lapping of cold joints throughout each paving sequence completed during a work period. The field compaction of asphalt is related to the temperature of the asphalt, the compaction pattern, and the sequence of using different compaction equipment (Kassem & Masad, 2008). The compaction of the joints in a runway pavement is directly correlated to the integrity of the runway, runway flatness, and the premature failures of pavements which can be costly and time-intensive to repair (Roozbahany & Partl, 2019).

As a result of the literature review and analysis of joint compaction issues, there are two alternative paving sequences that are to be explored in this case-study analysis. The first alternative maintains the standard method of single-runway airport resurfacing in preparing an alternative redundant paving sequence to be completed within short work periods that would result in an overall reduction in joints to be "cold-jointed" (White, 2019). The other alternative to be analyzed is based on the observed joint compaction advantages of completing work in one continuous work period as was demonstrated during non-runway phases of construction for this project – see original project phasing breakdown below.

An additional consideration in assessing alternatives such as the 72-hour closure paving sequencing alternative, would be the advantages of reducing nighttime construction operations. Specifically, as it applies to asphalt paving projects that take place during nighttime hours— "there have been several significant factors observed that reduce the productivity of asphalt paving operations such as visibility, personnel fatigue, and glare" (Mostafavi & Valentin, 2012). In relation to safety concerns related to nighttime paving operations, there have also been concerns raised as to the quality of asphalt produced during nighttime operations observed through rideability concerns and decreased joint compaction (Ogunrinde et al., 2020).

Research Methodology

The intended research strategy for this analysis was to focus on the development of quantitative data. The main reason for the use of mainly quantitative data is that throughout the development and comparison of alternative paving sequences, it is integral to incorporate the field-observed rates of milling and placing asphalt as to effectively compare schedule and cost impacts. In analyzing alternative methods, it is important to conduct several quantity take-offs (QTOs) related to the quantity of asphalt to be placed overall and how that quantity can efficiently be divided up into different paving sequences. Additionally, these paving sequences are to be compared to the identified areas to be paved with the rate in which asphalt was milled-and-placed during the actual Runway Rehabilitation Project. The alternative paving sequencing procedures being longer working period covering more surface area and alternative runway pavement breakdown sequencing can be compared to the original method in which the San Luis Obispo Regional Airport was paved to compare the duration and amount of joints between pavements to determine if there was an alternative method that could have been used to decrease the amount of pavement jointing and promote cost savings.

Another key aspect of the research is the collection of qualitative data gathered through semi-structured interviews with members of the project team that recently completed the work in October 2021. It is important to reference the industry members that had worked on this project to gain insight as to why certain sequencing decisions were made and if there were any field or alternate conditions that impacted the sequencing of this project. The following project team members provided semi-structured interviews for this case-study and analysis: Adam Souza (Granite Construction – Bakersfield and San Luis Obispo County Area Construction Manager), Eric Wildhagen (Granite Construction – Central Coast Region Project Manager), and Brycen Killion (Granite Construction – Central Coast Region Project Engineer).

Case Study

As outlined by the contact of the project, “this Project has been phased to minimize operational impact to the runway and Airport users overall.” Therefore, the project was originally phased into four non-overlapping work phases over a period of 57 calendar days addressing certain areas of the project and scopes of work. The original phasing of the project, with the omission of the electrical scope of work, is as follows:

I. Phase 1 – Paving work at the Runway 29 Threshold (Blast-pad area), Taxiway A and Taxiway to be completed over the course of 2 consecutive calendar days (48-hour closure). Work elements addressed in this phase included the cold mill of asphalt concrete pavement and haul of material, joint and crack repair, pave hot mix asphalt surface overlay, the removal and painting of temporary pavement markings. The observed work area for this phase of construction spanned from station 63+00 to 71+15 on Runway 11-29, the Eastern Blast Pad from station 71+15 to 73+98, Taxiway A, and Taxiway L which cumulatively spanned around 212,000 SF of area to be paved. The overall quantity of asphalt placed was just under 6,000 tons for this phase.

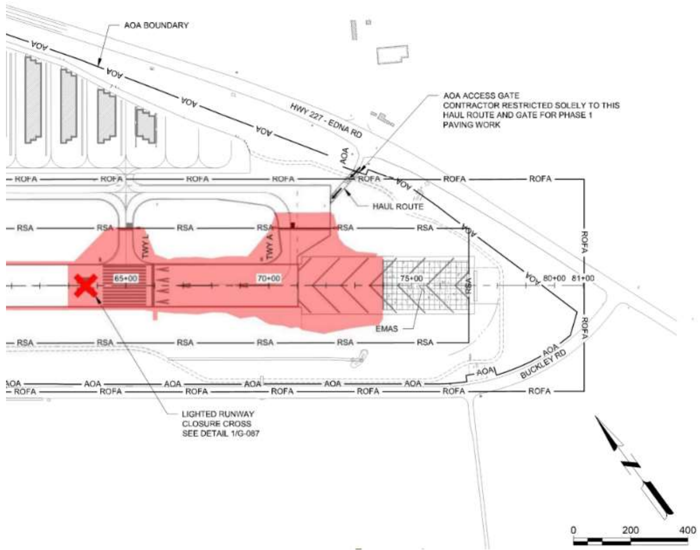

Figure 1. As-Constructed Phase 1 Plans

II. Phase 2 – Paving work of the 11-29 Runway to be completed over a period of 30 calendar days (12-hour period night shifts). Work elements addressed in this phase included the cold mill of asphalt concrete pavement and haul of material, joint and crack repair, pave hot mix asphalt surface overlay, the removal and painting of temporary pavement markings. The observed work area for this phase of construction spanned from station 21+00 to 63+00 and covered about 630,000 SF of area to be paved. The overall quantity of asphalt placed was around 15,000 tons for this phase, or about 1,250 tons of asphalt placed in a 12-hour work period.

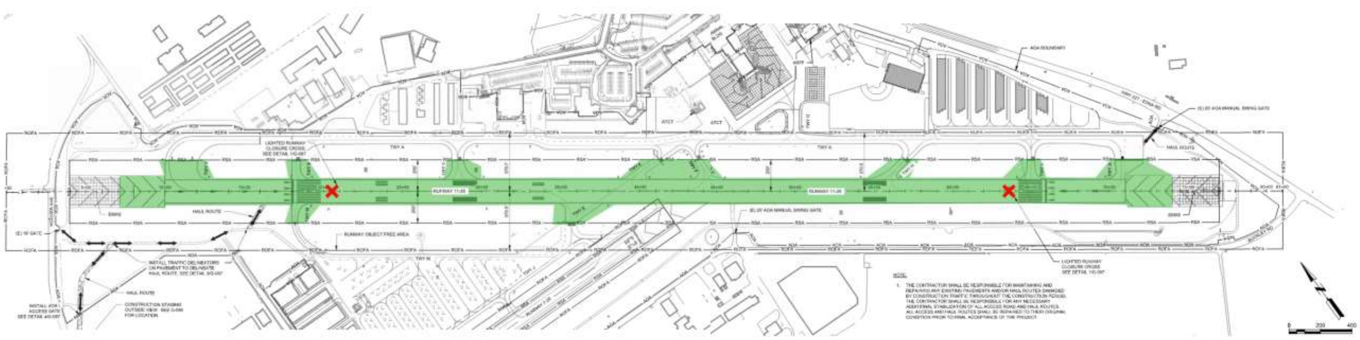

Figure 2. As-Constructed Phase 2 Plans

III. Phase 3 – Paving work of the 11-29 Runway, Taxiway A and Taxiway L over a period of 2 consecutive calendar days (48-hour closure). Work elements addressed in this phase included the cold mill of asphalt concrete pavement and haul of material, joint and crack repair, pave hot mix asphalt surface overlay, the removal and painting of temporary pavement markings. The observed work area for this phase of construction spanned from station 9+99 to 21+00 on Runway 11-29 and the Western Blast Pad from station 7+14 to 9+99, covering an overall 222,345 SF of area to be paved. The overall quantity of asphalt placed was around 4,700 tons for this phase.

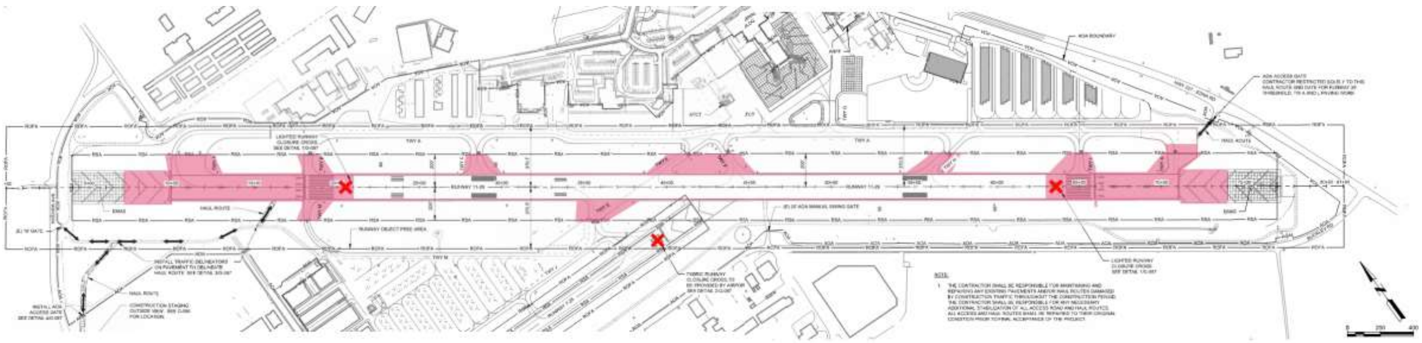

Figure 3. As-Constructed Phase 3 Plans.

IV. Phase 4 – Grooving and painting of the 11-29 Runway, Taxiway A, and Taxiway L over a period of 23 days (12-hour night shifts).

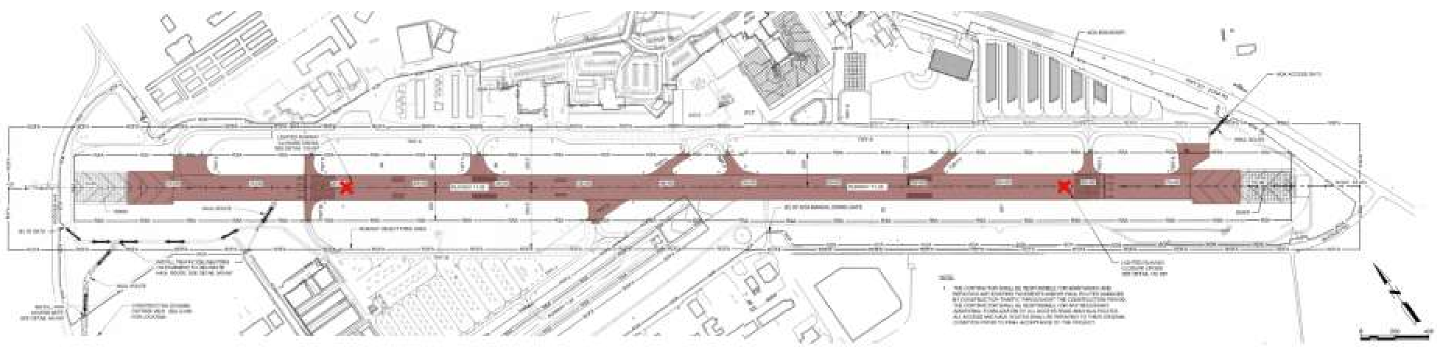

Figure 4. As-Constructed Phase 4 Plans.

As-Constructed Runway Sequencing

As demonstrated by the five construction phases for this project, seen above, Phase 2 was used to break up the milling and paving of Runway 11-29. To individually study the phasing of the milling and paving of the runway without the other areas of the scope, Phase 2 will be the only phase that is alternatively sequenced. During this phase, the width of the runway was broken up into 12 paving lanes that were milled at the entire effective length of the runway spanning from each threshold area (areas denoted by corresponding “11” and “29” markers). These paving lanes were as each lane was milled during the first part of the 12-hour work period, paving would shortly follow the milling to ensure that each lane was paved within the work period. Due to areas of settlement on the previous runway, an additional consideration for the as-constructed runway sequence was the fact that any pavement markings such as threshold markers or boundary lines had to be repainted at the end of each work period to ensure that the airport was operable.

Alternative Runway Sequencing

As beforementioned, the alternative paving sequences to be explored in determining alternative runway sequencing for Phase 2 of the runway resurfacing pertain to a widened pacing segment sequencing alternative and a two-week airport closure sequencing alternative. These alternatives were derived as part of the literature review completed for the project as well as interviews with members of the project team. The first alternative maintains the standard method of single-runway airport resurfacing in preparing an alternative redundant paving sequence to be completed within short work periods that would result in an overall reduction in joints to be "cold-jointed" (White, 2019). The other alternative to be explored is based on the observed joint compaction advantages of completing work in one continuous work period as was demonstrated during non-runway phases of construction for this project.

In coordination with the literature review completed for this project, during a series of semi-structured interviews with members of the project team such as the construction manager, project manager, and project engineer. The construction manager of the general contractor for this project was Adam Souza from Granite Construction who prompted the consideration of the extended closure option for the runway paving phase. Because this project was designed and completed as a CMAR, the construction manager had a lot of influence with the original phasing of the project. During the interview with Souza, he stated the following in reference to FAA requirements and the phasing of work— "the original approach that we were going to take in paving the [SLOCRA] airport would have been to pave the entire project across four or so phases, with Phases 1 and 3 remaining the same and breaking Phase 2 into two phases breaking at the crown of the runway."

The project manager of the general contractor for this project was Eric Wildhagen from Granite Construction. Wildhagen has been working in the Central Coast with Granite Construction for several decades and has had experience working at the Santa Barbara Municipal Airport, Santa Maria Airport, and the Paso Robles Municipal Airport. Leveraging his experience completing asphalt runway resurfacing projects, Wildhagen aligned with Souza on an extended airport closure as that is how work at the Santa Barbara Municipal Airport was completed. In reference to the joint compaction issues observed over the course of the runway paving, the project engineer with the general contractor, Brycen Killion, suggested that work could have possibly been completed in more of an alternating paving segmentation to reduce the amount of cold jointing needed for the project.

Widened Paving Segment Sequencing Alternative

This paving sequencing alternative for Phase 2 of the construction of the 11-29 Runway encompasses the entire stretch of runway spanning from station 21+00 to 63+00, covering an overall 630,000 SF of area. Utilizing the observe production rate for placement of asphalt: the overall quantity of asphalt places in this phase was 15,000 tons, with the placement of 1,250 tons of asphalt placed in one of the twelve paving lanes completed during a 12-hour work period. During this work period, asphalt was observed to be placed normally between 8pm and 4am during each shift bringing the placement rate of asphalt to about 208 tons of asphalt placed per hour. Where this paving sequencing alternative deviates from the original paving sequencing method is in how the runway is broken up and the size of the new areas that can be completed in a 12-hour work period.

The 11-29 Runway is 150 feet wide, and the length of the runway completed during this phase is 4,200 feet long, the original square footage of asphalt to be placed in one work period was 52,500 SF and with an applied 4” overlay the volume of asphalt placed was 17,483 CF or approximately 1,250 tons of asphalt placed within a work period. Breaking the runway into comparable paving areas to be completed within a work period, the widened paving segment sequencing alternative divides the runway into twelve paving areas that are 75 feet wide (breaking at the crown of the runway) and 700 feet long. The advantage of paving in this sequence is the reduction in the length of asphalt that will have to be cold-jointed, therefore reducing the implications of any joint compaction issues.

Figure 5. Widened Paving Segment Alternative Area Plans

Extended Airport Closure Sequencing Alternative

This paving sequencing alternative for Phase 2 of the construction of the 11-29 Runway encompasses the entire stretch of runway spanning from station 21+00 to 63+00, covering an overall 630,000 SF of area. Utilizing the observed production rate for placement of asphalt: the overall quantity of asphalt placed in this phase was 15,000 tons, with the placement of 1,250 tons of asphalt placed in one of the twelve paving lanes completed during a 12-hour work period. During this work period, asphalt was observed to be placed normally between 8pm and 4am during each shift bringing the placement rate of asphalt to about 208 tons of asphalt placed per hour.

Utilizing the observed rate of 208 tons of asphalt placed per hour, 15,000 tons of asphalt could be placed over a period of 72-hours. However, that assumes a continued availability of trucks and asphalt which is not logistically responsible to consider, meaning that an additional 24-hour closure should be included when considering a monolithically paved sequence, especially as the crew requires frequent breaks and will have to be traded out after 12-hours as was done with previous 48-hour closures. Additional considerations for the completion of the Phase 2 scope of work is the time taken to mill and haul the existing runway as well as the time needed to re-paint any markings and complete an inspection before the airport is operational. Therefore, it is reasonable to assume that the entire 11-29 Runway could have been paved in a 96-hour closure, spanning a period of 4 days or eight 12-hour work periods.

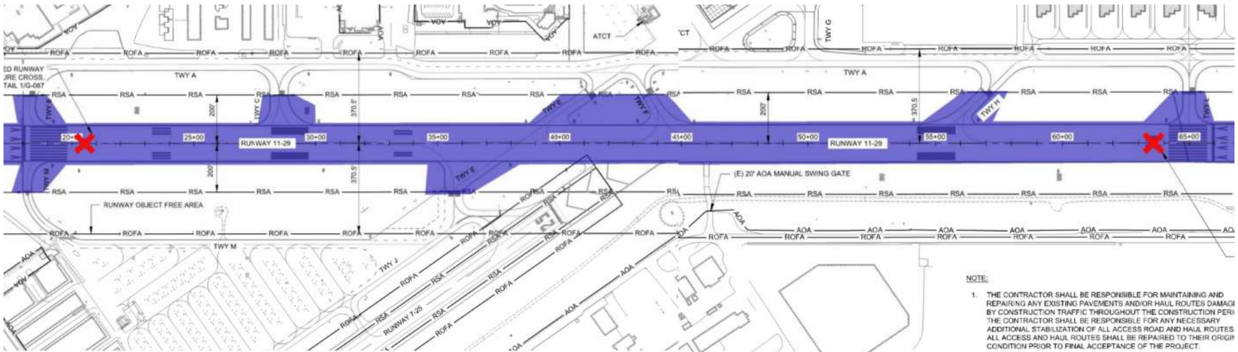

Figure 6. 96-Hour Alternative Paving Area Plans.

Project Timeline and Conclusion

Comparing the paving sequencing alternatives to the original pavement sequencing, there are favorable aspects to each alternative as well as downfalls. When looking at the extended work period alternative, there is a reduction in the number of 12-hour working shifts needed, leading to cost savings and positive scheduling impacts. However, Souza also shared that phasing the project like that would have been impossible because the SLOCRA intended to remain operational during construction because the loss of income during an extended closure would have been extensive, essentially negating the potential for this alternative.

When comparing the widened paving area alternative to the original method of paving, there are no observed cost savings as there is still a required twelve 12-hour work periods. However, the advantage of this option would have been a reduction in the overall length of cold jointing required throughout the runway. The addition of intermediate lateral joints across the runway would have taken-away from the smoothness of the runway and could lead to increased deterioration in areas where there is heavy vehicle traffic (Rahman et al. 2019), leading to the conclusion that this paving alternative could not have been used or would have created other issues that needed to be corrected for.

Conclusion and Future Research

In conclusion, the original phasing that was used for the San Luis Obispo County Regional Airport was likely the only phasing option that could have been considered. While the extended closure of the airport would have led to increased cost savings, positive schedule impacts, and would have solved joint compaction issues—logistically it would not have been allowed by San Luis Obispo County as the loss of income associated with the public interfacing flight schedule as well as the private flights and hangers (operated through ACI) would have been so substantial as to negate any cost savings.

Due to the nature of this project as a case study, any data created during the process of conducting this project will be new knowledge as it is unlikely that anyone has analyzed how this specific project could have been altered. The new knowledge provided as to how the asphalt paving sequence of this project could have been done differently, if it could have been done differently, to decrease issues associated with joint compaction and promote cost savings. In a more general sense, future research could provide insight as to alternative asphalt pavement sequencing when applied to airport or other heavy-civil construction operations.

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