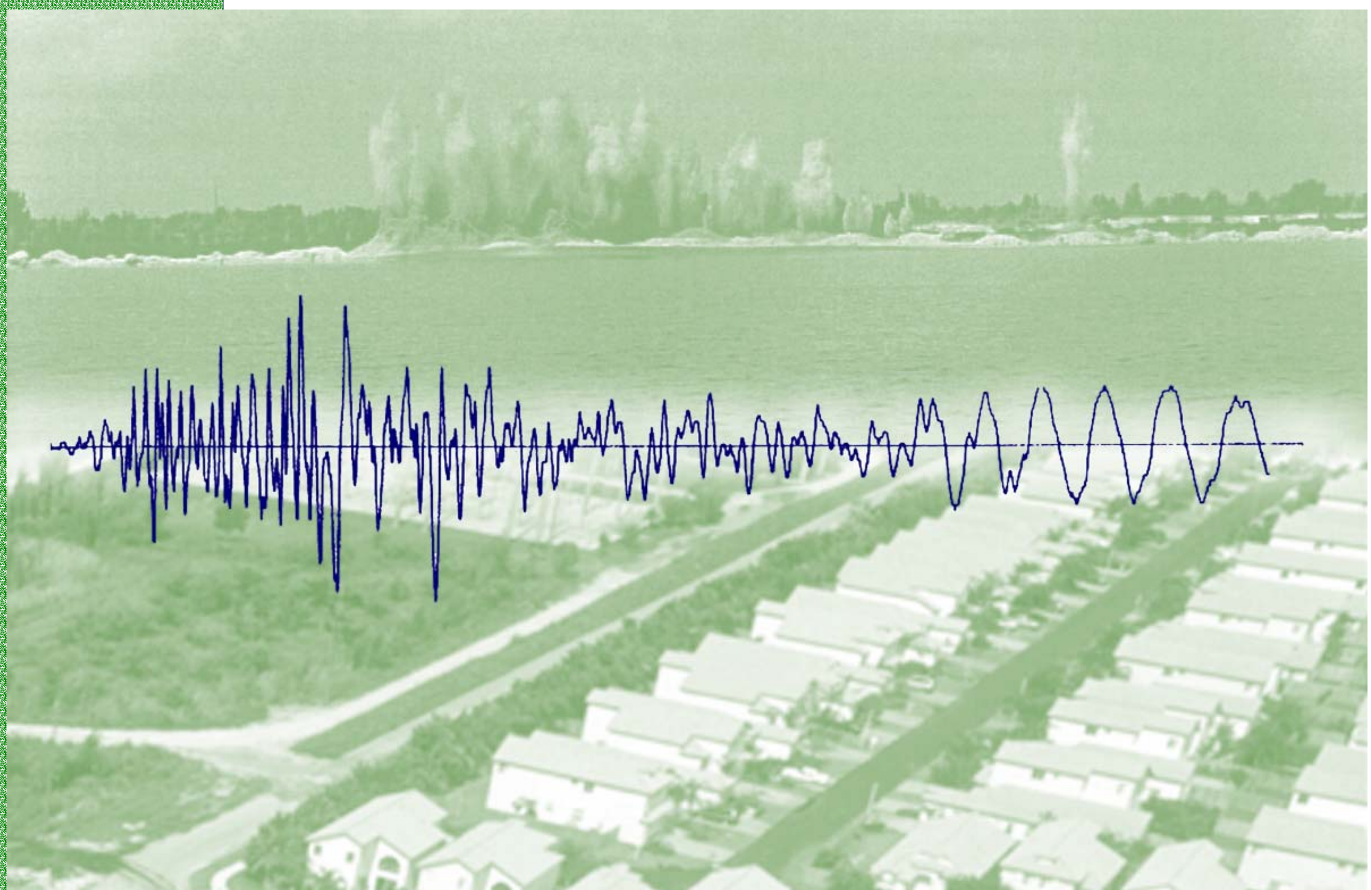
BLAST VIBRATION DAMAGE ASSESSMENT STUDY AND REPORT



PREPARED FOR:
THE MIAMI-DADE COUNTY BLASTING TASK FORCE

FINAL REPORT

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EXECUTIVE SUMMARY

DESA examined Dade County blasting for the County through a contract with C3TS. Vibrations and structure responses were measured at 11 locations in the County between February and April, 2000. Also,10 homes were inspected to analyze the characteristics of their cracking and other damages. These results were combined with information collected by the County and other studies done in south Florida for a blasting impact assessment.

As a general conclusion, blasting in local quarries does not appear responsible for cracks and other damages existing in the Dade County residences examined. This is based on vibration amplitudes and frequencies, structure responses, theoretical analyses of material strength and strains, and the nature and degrees of the existing damages in the homes inspected. The existing Dade County blast vibration regulatory limit of 0.75in/s PPV, however, does need to be revisited.

Vibration Amplitude Analysis: The highest predicted vibrations for Dade County blasts at resident's homes are 0.18 in/s for the NW area and 0.35 in/s for the west Miami area based on the "Dade County Data Envelope" and the largest charge weights being used in each area. All amplitudes measured were below these levels, particularly in the west area. The envelope itself was derived from the highest individual measurements. Vibration amplitudes are relatively high for these distances and charge sizes. Attenuation with distance is less in Dade County than found elsewhere with quarries having to use scaled distances several times higher than similar sites in the north. The vibrations are perceptible at very large distances from even relatively low charge weights per delay.

Vibration Character: Vibrations are of long durations at the homes (some over 17 seconds) and are a mixture of frequencies including "low" frequencies of about 8 Hz, which are close to house resonant frequencies, and very low frequencies of 2 to 4 Hz. The house responses to these low frequencies are particularly noticeable to persons and are understandably alarming.

Structure responses: The response nature of south Florida structures is sufficiently different from frame structures studied elsewhere to justify some concern. Walls of concrete blocks with concrete caps and extensive openings, and sometimes higher than standard 8-ft ceilings, respond as if they have low effective damping. The highest dynamic superstructure amplification exceeded 6x an Id there were several blasts and structures above 3.6x. More structure response measurements are needed to establish exactly how serious and widespread are these high responses. However, a reduction of the County's limit of 0.75 in/s should be considered and a suggested interim value would be 0.50 in/s.

<u>Wall strain calculations:</u> Worst case vibration amplitude of 0.18 in/s and response of 6.1 x in the NW area corresponds to a global or overall in-plane wall strain of about 42 $\mu\varepsilon$. This is sufficiently below the initial cracking levels of 100 ~£ for CMU masonry walls that blasting should not have produced cracks in such walls. However, a vibration of 0.75 in/s with the same response factor would produce a global wall strain of over 150 $\mu\varepsilon$. This could cause cracking and justifies a reduction of the allowable limit by about 30 to 50 pct.

<u>Assessments of house damages:</u> Of the 10 houses inspected for the characteristics of damage, five have some wall cracks, mostly exterior, which *could be* from dynamic sources. These are: # 4, 11 (garage), 45, 34, and 42. "Dynamic" here is used for short-period or transient forces, which cause superstructure racking and shear forces in the planes of the walls. Examples are blasting and winds. Long-term dynamic sources such as temperature, humidity and soil moisture cycles and unidirectional forces such as soil compaction, differential settlement, and material drying and curing all produce cracks with differing characteristics. The nature of responses from blasting and gusty winds are similar and the worst-case vibration-induced responses of 1 .10 in/s (considering dynamic amplification) are equivalent to the effects of winds of about 57 mph. Considering recent Florida storms such as Irene and Andrew, this makes wind responses more likely than blasting to be responsible for the cracks.

<u>Damages other than wall cracks:</u> All other damages are not from blasting or wind-induced responses including any kinds of floor cracks and the very similar and characteristic below-window damages found in many of the homes. These are all construction related, environmental (e.g., water intrusion), or natural material responses such as shrinkage and compaction. There is a possible role in construction practices here also such as the question of sufficient foundation soil preparation, and proper stucco mixtures.

Floor damages of any and all sort are not characteristic of vibration responses. Racking of buildings from blast vibrations consists almost entirely of horizontal motions. Upper story floors simply go for a ride as load-bearing walls experience shear deformation and, if sufficiently racked, crack damage at stress concentrations (openings). Floors at ground level and anything below ground, e.g., pools, experience none of their racking and strain. These are only subjected to low-level compression, tension and flexing (bending) as described in Appendix B.

A general conclusion is that in most homes and in most places in the homes, there is a lack of the types of cracks in load-bearing superstructure walls that would be expected from vibration caused racking or any other conceivable vibration response. The few possible exceptions are individually discussed.