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From: Alan Bridle <abridle@NRAO.EDU>
Organization: NRAO
X-Mailer: Mozilla 4.01 [en] (WinNT; U)
MIME-Version: 1.0
To: David Hogg <dhogg@NRAO.EDU>
Subject: Re: This time I'll keep track
X-Priority: 3 (Normal)
References: <199807201452.KAA28381@polaris.cv.nrao.edu>
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David Hogg wrote:

> Alan,
> I looked unsuccessfully for your e-mail about 300-foot
> fatigue. So, while our discussion was fresh in my mind
> I decided to document it (for my purposes).
>
> Does the following sound right to you?
>
> Dave
>
> July 20,1998
>
> I asked Alan Bridle about the 300-ft collapse. He has no
> memos or reports. He has copies of his personal notes.

Dave, if we're keeping track more carefully now, here in quotes are my entire
notes of a conversation I had with Dave Westphal in Green Bank at 11:15 am on 28
December, 1988

"D.W. has been gathering information on fatigue in steel, following his
conversation with Mecklin from external team. D.W. estimates that the
telescope slewing history corresponds to about a million "cycles" of the
structure, which is about where the fatigue of steel "bottoms out". (Breaking
strength decreases for about a million cycles and then does
not decrease further).

At Mecklin's suggestion, D.W. has been examining breaks in structure visually,
in attempt to characterize them as sudden fractures versus slow, plastic
deformations followed by fracture. He believes that he can distinguish these
types of failure around the East tower."

> He has a note about a trip he made to GB in which he discussed
> fatigue cycles with David Westpfahl, then on the GB staff and
> now at New Mexico Tech in Socorro. Westpfahl made an estimate
> of the number of slewing cycles (acceleration and stop, NOT
> necessarily through the zenith) and came up with the one
> million number. It was felt that at one million start/slew/stop
> cycles the metal would undergo a permanent change such that
> it would be more vulnerable to stress-induced fracture.

As my note records it, the change is in the sense that the progressive weakening of the metal by working "bottoms out" at around a million cycles. I.e. that the change is progressive until, but not after about one million cycles.

> Alan noted that the NRAO committee did not make a report, since
> they did not want possible conflict with the external committee.
> He does not have a copy of the final report. He does not think they
> spoke of fatigue cycles, but he is not sure. I will have to get
> the report from Vanden Bout if I want it.

>
> It may be possible to get more info from Westpfahl, if necessary.

>
> I had earlier checked with Condon who could not remember making
> a report. He did a quick estimate of his cycles and came up with
> 25K, much less than the Westpfahl number. If as Alan remembers
> the Westpfahl number is dominated by the slewing surveys there
> may be a problem that has to get straightened out.

>
> But in any event:
> -- it is not merely going through the zenith that counts. One must
> take into account the acceleration.
> -- Alan does remember a number of order one million. The author
> of the number is Westpfahl.
> -- Alan believes that the one million cycles is consistent with
> the findings of the external committee, but perhaps is not
> explicitly contained in their report.

My recollection is that the external committee focused on the essentially explosive (i.e. sudden) enlargement of a pre-existing crack in the gusset plate, but did not determine a specific cause for this sudden enlargement. I believe that the report suggested, from metallurgical evidence, that a crack that was of order a few inches long in the neighborhood of two bolt holes (and therefore hidden from view), rapidly grew to a length of several feet, after which the structure was definitely unstable. This enlargement may however have been a late phase in a progressive collapse whose primary cause remained undetermined.

I also recall being told (but I am not sure whether this was part of the external report or information that I gathered from Fred Crews), that the bolt holes in the gusset plate were formed by punching through the half-inch steel plate, a process that is now known to create micro-cracks around the holes but which was normal manufacturing procedure at the time for this thickness of steel. My recollection is also that the external committee found evidence that the segment of the failed plate closest to two of the bolt holes had indeed cracked progressively (over a period of some years), while the bulk of the crack in the plate as found in the wreckage was fresh.

Again by my 10-year-old recollection, the primary cause for the sudden enlargement of the crack in the gusset plate was never determined ... it could for example have been provoked by the failure of another member elsewhere in the structure. I'm also not clear how "progressive cracking" around a punched hole

relates to the more general cycle-related decrease in breaking strength alluded to in my notes from the Westphal conversation. The detailed connection, if any, between the long-term cycling of the telescope and the gusset plate failure is therefore unclear (to me). One would need to read the external committee's report carefully to see if it was addressed there.

There was also evidence from Jim Condon's survey data reduction that the telescope was significantly mis-pointing for some days before the final collapse. This suggests that there was an ongoing structural deformation of some kind before the final catastrophic failure of the gusset plate. The connection, if any, between this ongoing deformation process and the final failure is unclear to me. The pointing analysis was not known at the time of the external committee's report.

I believe that the external committee did not identify an explicit sequence of events leading to the failure of the gusset plate, only that this failure, once it had been provoked, was sufficient to doom the telescope from that moment on. I would therefore urge a re-reading of the external committee's report if the "million cycle" estimate is becoming important again. Dave Westphal was talking to Mr. Mechlin from the external committee when this matter originally came up, so something may indeed have been said about the subject in the external report. But my own notes do not justify comment on whether the slew cycle estimate was consistent with, or even material to, what the external committee finally reported.

I hope this is helpful,

Alan B.