INVESTIGATION OF TH
RIGHT NASMYTH PLATFORM
OF THE KECK II TELESCOPE

Mauna Kea, Hawaii

by

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SUMMARY

The strength and stiffness of the right platform of the Keck II Telescope were examined to ascertain their ability to support safely additional loads significantly greater than the original design loads. We conclude that all elements of the yoke and platform require no strengthening, with the exception of beams BN.8 and BN.10. An investigation of the rail assembly, added to the platform after the original design and construction, was not within the scope of the present investigation; nevertheless, we offer some recommendations regarding this system.

INTRODUCTION

The structure of Nasmyth Platforms of the Keck I and Keck II Telescopes was designed originally for the following loads.

- Dead Load of the structure and the grating,
- Live Load of 40 psf on the grating deck,
- Live Load of the instruments, total not to exceed 10 metric tons (22000 pounds) per each platform; this load was to be applied only at special "hard points" provided at the time of the original installation on top of the main beams of the platform. The maximum value of the concentrated design load on any one "hard point" was 5 metric tons (11000 pounds), with one such concentrated load per main beam at any one time.

CARA proposes to increase the instrument loads and the manner of their application, on the right Nasmyth platform of the Keck II Telescope, as follows.

There would be three instruments located on this platform simultaneously, their static weights being 20000 pounds, 8000 pounds, and 2000 pounds. They would be located on three tracks, which in plan radiate from the center of the telescope. The instrument currently used during observing would be located on the center track (along the global x-axis). The other two tracks are located in plan at 18.4° to x-axis (forward track), and at an angle of 17.5° to the x-axis (rearward track). The storage position for the new Deimos instrument, which weighs 20000 pounds) is the forward track.

The distance from center line to center line of the rails is 1500 mm (approx. 59.055 inches).

It appears that the rail support assembly was designed and installed at some point in the past. It consists of a channel C6x10.5, laid flat on top of shims located on top of the main beams of the Nasmyth platform, and strengthened from below by rectangular tubular sections 4"x2"x0.25", placed with the 4" dimension sometimes vertically and sometimes horizontally. We were advised that, as of now, the details of the design and installation of these assemblies are not available. In particular, there is no information of the details of joints between the assembly and the main beams of the platform, including the details of welding.

It is our understanding that the rail itself is a steel flat bar, FB3"x1.5", not yet installed, to be grouted in flat within the C6x10.5.

In the following we report on the magnitude of the additional stresses and deflections of the main beams of the Nasmyth platform, and the principally affected elements of the yoke structure. We present our conclusions and recommendations, including our recommendations for further investigation and design of the rail support structure.

PLATFORM AND YOKE LEMENTS

In the following, we give the results of our investigation of the stresses and deflections due to the additional loads on certain structural elements of the platform and the yoke. These elements, and their properties, are listed in Table 1 below. The location of these elements, and their cross-sectional properties, were obtained respectively from the structural design drawings for the Keck I telescope prepared by S. J. Medwadowski and dated February 3, 1987. Specifically, the location of the elements is shown in plan 1 on Sheet 7.1, and the cross-sectional properties in the Table on Sheet 7.12. All elements were specified as steel ASTM A36.

For each element, we applied the new, increased instrument loads at the positions causing greatest stress. We note that in the original design beams BN.7, 8 and 10 were not subjected to instrument loads.

TABLE 1 – PROPERTIES OF ELEMENTS

Element	*Flange* *t x b* *(mm x mm)*	*Web* *t x h* *(mm x mm)*	*Section properties* *Area* *(in^2)*	*Shear area* *(in^2)*	*Mom. Of in.* *(in^4)*	*Sect. mod.* *(in^3)*
BN.3-6	40 x 250	14 x 258.8	36.6	5.6	1127.5	169.1
BN.7	20 x 100	10 x 298.8	10.8	4.6	297.9	44.7
BN.8	20 x 100	10 x 298.8	10.8	4.6	297.9	44.7
BN.10	12 x 150	6 x 66	6.2	0.61	13.6	7.7
TB.7	n/a	n/a*	11.97	n/a	n/a	n/a
TT.4	20 x 100	12 x 310	5.73	n/a	n/a	n/a
TT.7	40 x 150	10 x258.8	22.6	4.0	682.0	102.3
TT.8	30 x 200	12 x 240	23.1	4.5	560.8	95.0

*not applicable; the element is primarily a column

Main Beams

These are beams BN.3 through BN.6. Each is a simply supported beam with overhangs, the main span being 288.2", and the overhangs 39.8". Beam BN.3 represents the worst case for the instruments located in the main span between the supports. Beam BN.6 represents the worst case for an instrument load at the end of the overhang. We consider the two cases in the following.

BN.3: The instrument loads are as follows. At the center track, each rail is subjected to a concentrated load of 5 kips (Deimos in the observing position), reduced by the tandem load effect, and increased by a factor of 1.25 to allow for impact, resulting in the load of 5.82 kips at each rail. On the forward and rearward tracks we allow for a stored instrument weighing a total of 8 kips; allowing for a reduction due to the impossibility of having both front wheels on the beam at the same time, and disregarding impact (because the instruments would be wheeled onto the Nasmyth platform sequentially), we obtain the load of 1.87 kips on the beam at the inward rail, and 1.27 kips on the outer rail. Conservatively, we assume the same loads on the beam at the rails of the rearward track. The results are as follows.

Max. bending stress: $f_b = 7.298$ ksi

Max. shear stress: $f_v = 2.300$ ksi

Max. deflection: $w = 0.313"$ (1/920.8th of span)

The stresses and deflections are well within acceptable limits.

BN.6: This beam is subjected to load at the end of the forward overhang. The load is, approximately, 6.25 kips, including an impact factor of 1.25. The results are as follows.

Max. bending stress: $f_b = 1.419$ ksi

Max. shear stress: $f_v = 1.112$ ksi

Max. deflection: $w = 0.038"$

All stresses and deflections are well within acceptable limits.

Secondary Beams

BN.7 and BN10 Assembly: These beams were designed originally only for their share of the loads from the platform grating. The loads from the tracks would be from the center track, and the storage track.

Analysis shows that flexural and shear stresses in BN.7 and BN.10, due to the additional instrument loads, are within acceptable levels. However, the vertical deflection at the point where BN.7 is supported on BN.10 is very substantial, being 0.472" when Deimos is located on the center track, an unacceptably large number.

BN.8: This beam may be exposed to action by one of the rails of the forward track, where Deimos is to be stored. The condition is not entirely clear, because the as built dimensions are not entirely available at this time. However, at worst, a concentrated load from Deimos would be not more than 6.25 kips, including impact. Beam BN.8 is capable of transferring this load to its support, BN.6, as are the connection bolts. The deflections of BN.8 are also negligible.

Yoke elements

TT.8 and BR.7 Assembly: This assembly supports the main beams of the Nasmyth platform, beams BN.3 through BN.6. The most severe load condition occurs when Deimos is located on the storage track, and the other two tracks are occupied by instruments weighing 8 kips each (a conservative assumption, made with an eye on the future). For the purpose of analyzing the assembly, we assume a very conservative load of 13.61 kips acting at mid-span of element TT.8, and an equal load at the joint where TT.8 and BR.7 meet. The resulting stresses and deflections are as follows.

TT.8: Max. bending stress: $f_b = 7.335$ ksi

Max. shear stress: $f_v = 1.527$ ksi

Max. deflection: $w = 0.169"$

RB.7: Max. axial stress: $f_a = 1.152$ ksi

All stresses and deflections of the elements of the assembly are well within acceptable limits. In particular, the deflection of TT.8 under a very conservative instrument load is only $1/1180^{th}$ of the span.

TT.7 and TT.4 Assembly: This assembly supports element TT.8, and also the rails. It also meets all of the strength and stiffness requirements when subjected to larger instrument loads.

CONCLUSIONS AND RECOMMENDATIONS

We conclude that, with the exception of beams BN.9 and BN.10, all elements of the yoke and Nasmyth platform, when subjected to the larger instrument loads, can safely transfer these loads, with all stresses and deflections remaining within acceptable limits.

The exception, beams BN.9 and BN.10, are not stiff enough to transfer the loads of Deimos, particularly when only a modest allowance for impact is made.

We offer the following recommendations.

1. Beams BN.9 and BN.10 should be strengthened and stiffened to allow for a concentrated load at the end of the cantilever (outside beam BN.6), with stresses limited to not more than 10 ksi in bending, and the vertical deflection at the end of the cantilever not more than 0.05",
2. The rail channel+tube assembly should be re-examined as follows.
   a. We recommend that the whole assembly be examined in the field by a reputable testing agency, which is very conversant with the field examination of welded joints; the testing agency should produce a report containing an accurate drawing showing the layout and the welds
   b. After the information from the testing agency has been obtained, the adequacy of the assembly, including the strength and stiffness of elements and welds, should be evaluated by a structural engineer
   c. Depending on the results of step b, an appropriate strengthening and stiffening of the assembly should be designed.

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